TOXIC INDUSTRIAL CHEMICAL:
A FUTURE WEAPONS OF MASS
DESTRUCTION THREAT

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ABSTRACT

TOXIC INDUSTRIAL CHEMICALS: A FUTURE WEAPONS OF MASS DESTRUCTION THREAT, MAJ Larry Small, 86 pages.

Nuclear, biological, and chemical (NBC) proliferation is recognized as a serious threat across the operational spectrum--from the deployment of forces to posthostility activities, but there is a misconception when it comes to toxic industrial chemicals (TICs) as equal to CW (CW) agents threats. Release of these TICs could inflict the same damage as a military CW agent, albeit larger quantities of the TIC would be required. Thus, this thesis addresses the following question: Do TICs pose a weapons of mass destruction (WMD) threat, and what are their effects on joint military doctrine for operations in chemical environments? A significant array of books, periodicals, government documents, and Internet materials dealing with WMD as they relate to CW agents' (i.e., TICs) toxicities at low levels were reviewed. This thesis concludes that in the hands of terrorists, aggressive states or nonstate actors, TICs will serve as WMD, undermine regional stability, and threaten US interests. In general, joint doctrine for combat and noncombat operations inadequately take account of current TIC realities. Based on the documents cited in this thesis, the US Armed Forces have not collectively identified overall force structure requirements for dealing with this threat.

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Finally, while acknowledging those who provided me help, I remain solely responsible for any errors or shortcomings in this thesis.

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ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BW	Biological Warfare
BWC	Biological Weapons Convention
CBD	Chemical and biological defense
CBRNE	Chemical, biological, radiological, nuclear, and enhanced high explosive
CCEP	Comprehensive Clinical Evaluation Program
CDEPAT	Chemical Defense Process Action Team
CFS	Chronic fatigue syndrome
CIA	Central Intelligence Agency
COA	Course of action
COE	Contemporary operational environment
CTC	Combat training center
CW	CW
CWC	Chemical Weapons Convention
DOD	Department of Defense
DOJ	Department of Justice
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FM	Field Manual
GA	Tabun
GAO	Government Accounting Office

GB	Sarin
GD	Soman
GF	Cyclosarin
GWI	Gulf War Illnesses
HD	Sulfur mustard
ITF-25	International Task Force 25
JP	Joint Publication
JSIG	Joint Service Intergation Group
JSMG	Joint Service Materiel Group
JTF-CS	Joint Task Force Civil Support
L	Lewisite
LCt	Lethal concentration
MIIS	Monterey Institute of International Studies
NATO	North Atlantic Treaty Organization
NBC	Nuclear, biological, and chemical
NIOSH	National Institute for Occupational Safety and Health
NLD Act	Nunn-Lugar-Domenici Act
OCS	Off-site consequence analysis
ODCSINT	Office of the Deputy Chief of Staff for Intelligence
ODS	Operation Desert Storm
OHS	Office of Homeland Security
OPCW	Organization for the Prohibition of Chemical Weapons
OSRD	Office of Scientific Research and Development

PL	Public Law
PPBS	Planning, Programming, and Budget System
OSAGWI	Office of the Special Assistant for Gulf War Illnesses
QDR	Quadrennial Defense Review
SASO	Stability and support operations
SIPRI	Stockholm International Peace Research Institute
TIC	Toxic industrial chemical
TIH	Toxic industrial hazard
TIM	Toxic industrial material
TNT	Trinitrotoluene, a component of many explosives
TRADOC	Training and Doctrine Command
TTP	Tactics, techniques, and procedures
WMD	Weapons of mass destruction
WME	Weapons of mass effect

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CHAPTER 1

INTRODUCTION

The Department of Defense's (DOD's) *Quadrennial Defense Review* (*QDR*) which was released 30 September 2001, and perhaps written before the 11 September 2001 terrorist attack on the United States, shifts the defense planning from a threat-based model to a capabilities-based model. A capabilities-based model is one that focuses more on how an adversary might fight than who the adversary might be and where the occurrence of war could be (US Department of Defense 2001). In other words, the capabilities-based concept reflects the fact that the United States cannot know with confidence what nation, combination of nations, or nonstate actor, will pose threats to vital US interests. During the Cold War, the US military was configured to fight a specific threat, (i.e., the Soviet Union), and just after the Cold War two major contingencies aimed at Iraq and North Korea (US Department of Defense 2001). Instead, the *QDR* and the 11 September attacks confirm that the United States must shift the defense planning concepts to deter and defeat adversaries who will rely on surprise, deception, and asymmetric warfare to achieve their objectives.

Beginning in the 1990s, the DOD began to recognize the potential for asymmetric threats to the United States. "We can assume that our enemies and future adversaries have learned from the Gulf War. They are unlikely to confront us conventionally with mass armor formations, air superiority forces, and deep-water naval fleets of their own, all areas of overwhelming US strength today. Instead, they may find new ways to attack our interests, our forces, and our citizens. They will look for ways to match their strengths against our weaknesses" (RAND Corporation 1999). The result is that the US must maintain sufficient conventional military strength to continue to deter interstate conventional war, at the same time develop, and grow military capabilities that can prevent and defeat asymmetrical threats.

"Although US military forces enjoy superiority in many dimensions of armed conflict, the United States is likely to be challenged by adversaries who possess a wide range of capabilities, including asymmetric approaches to warfare, particularly weapons of mass destruction (WMD)" (US Department of Defense 2001). One of the many challenges in the defense against WMD is that terrorist groups are moving away from bombs and going with the most potent killers: nuclear, biological, and chemical (NBC) weapons to cause death, cast fear, and show that they are a force to be reckoned with now and in the future (Lewis and Johnson 1995). For example, the attacks against the US homeland in September 2001 demonstrate that terrorist groups possess both the motivations and capabilities to conduct devastating attacks on US territory, citizens, and infrastructure. Often these groups have the support of state sponsors or enjoy sanctuary and protection of states, but some have the resources and capabilities to operate without state sponsorship. In addition, the rapid proliferation of chemical, biological, radiological, nuclear, and enhanced high explosive (CBRNE) technology gives rise to the danger that future terrorist attacks might involve such weapons in an asymmetric warfare environment (US Department of Defense 2001).

Assessing the threat of terrorism involving CBRNE materials, often referred to as WMD, remains difficult despite extensive literature bases in terrorism studies and WMD studies. In the absence of sufficient empirical data and analysis, policymakers and analysts often make projections based on assumptions about the increasing spread of

WMD related technology and know-how, and the vulnerability of modern society to WMD attack. The threat, however, also depends on the desire of subnational or transnational actors to use WMD related materials, but the motivations and interests in WMD for regional adversaries, often called rogue states, remain poorly understood.

"There is a new enemy with whom one cannot reason. An enemy without defined borders. An enemy from within our own environments . . . forcing policy makers to question and rethink these new threats and challenges" (US Department of Justice 2000). Troops are generally well prepared to fight and to win in an NBC environment; this is because the US military doctrine requires training of troops in the arena of NBC. As the US military forces, however, go through a transformation for operational practices, potential adversaries will look to find new ways to encounter or attack. Additionally, as seen during the Iran-Iraq War or the Bosnia-Herzegovina endeavor, people or factions can become discontent with their surroundings and choose from a variety of methods to retaliate. Therefore, what might have seemed appropriate and sufficient during Desert Shield and Desert Storm or before 11 September is simply inadequate on an asymmetrical battlefield.

The horrific events in New York and Washington increased the public interest in, and fear of, the vulnerabilities of the US to WMD terrorism. These terrorist incidents serve to reveal and reinforce the belief that the US is facing a danger in WMD, and more likely than it was in the past. For instance, the use of common chemical agents may occur because standard military chemical agents may be difficult or dangerous to manufacture, access, or disperse. Terrorists or warring factions, therefore, may use these chemicals commonly found in communities within industrialized nations to create WMD.

Additionally, terrorists have used toxic industrial chemicals (TIC) to improvise explosives, incendiaries, and poisons in several recent incidents (Hughart 1996). Toxic industrial chemicals have visible impacts on health, and they are accessible and dispersible by smoke, gas clouds, or food and medicine distribution networks (US Army 1990). While the improvised chemical agents (i.e., TIC) may be less toxic than military agents, the perception by the public is that they are highly dangerous.

In a modern society, large amounts of industrial chemicals are routinely stored, handled, and transported. Some of these are products ready for marketing and others used for further processing. There are national and international laws designed to control the handling of chemicals and minimize the risk of injury to humans, the environment, and property. This system of laws and regulations, however, provides no guarantee; that an accident, terrorist attack, or collateral damage during a hostile conflict will not occur.

Furthermore, the US Department of Justice's analysis of trends in international and domestic terrorism concludes that the risk of terrorists attempting in the near future to cause a toxic industrial chemical release is both real and credible (2000). Additionally, during Operation Desert Storm (ODS), a major deficiency identified was the inability of US forces to provide the war-fighter with percutaneous protection against NBC warfare agents and toxic industrial materials (TIM) (General Accounting office 1998b).

Nevertheless, there is still the debate of why consider TIC as threats equivalent to CW agents, when they are not as lethal as CW agents are, and are perhaps just environmental health hazards. Therefore, to adequately query the questions presented by this debate about TIC, there must be a solid thesis with clear boundaries set by assumptions, definitions, limitations, and delimitations.

Context of the Problem

The military community has written little about the employment of TIC, and perhaps, direct evidence about intent will surely be difficult to obtain. It is conceivable, and perhaps likely, that many of the nations seeking to acquire NBC have not themselves thought through the question of employment for TIC. Nevertheless, there is the possibility that TIC could be released from industrial plants or storage depots through battle damage, as consequence of a strike against a particular facility or as a desperation measure during military operations. They could also be attractive as improvised chemical weapons and have potential for inclusion in clandestine weapons programs or contingency plans. In short, there may be no direct connection between nations choosing to use TIC in a contemporary operational environment and their military rationale for employing them. The major risk is from the deliberate or accidental release from industrial plants or storage containers and the release from improvised terrorist weapons.

The US doctrine for NBC defense that occurred long ago is generally sound, but the concept was to counter a different type of threat. In many ways, the threat assessment associated was process oriented and directed against an enemy who operated according to their own doctrine and was therefore somewhat predictable (US Department of Defense 2001). Additionally, the US Secretary of Defense said in the 2001 *QDR*, "The terrorist attacks of September 11, 2001 demonstrate that the contemporary operational environment (COE) we envisioned for the future is here now." Consequently, one might argue that the vulnerability assessments of terrorist threats must now incorporate many more NBC variables than before. In other words, the new threat argument would focus on the possible use of TIC as a WMD or TIC caused by collateral damage.

Recent world events have made all too clear the realities of a different type or use of WMD. Alarmingly, the spread of these weapons continues. The US efforts to halt the spread of WMD and prevent its use have greatly reduced the immediate threat to the US and perhaps to the world. Nevertheless, there are many plausible and varied motives for the acquisition, weaponization, and actual employment of WMD capabilities. For example, some nations may seek to possess WMD capabilities in order to be able to intimidate other nations. Some perhaps seek WMD to overcome the superiority of other countries and perceive NBC as a means to deter possible intervention into their region. Also, for both state and nonstate actors, some seek WMD capabilities as tools for terrorism. Whatever the motivation, various intelligence estimates indicate that many countries are actively pursuing WMD.

It is essential therefore, to take this understanding to the next level by further exploring the range of plausible uses of TIC as WMD. Whether a given nation has begun to think through the employment question seriously is beside the point. For in many, if not all cases, further proliferation of WMD will soon lead to the question of how to use TIC most effectively against a range of adversaries. Nevertheless, the US needs to anticipate this development and examine the consequences of TIC use on its own ability to employ military force as an instrument of national or coalition strategy. Additionally, as with chemical weapons, the most vulnerable population is unprotected civilians who may be deliberately targeted to create terror or havoc.

The US's vulnerability to terrorist attacks has increased, post 11 September 2001, causing extraordinary efforts by the federal government to prepare for and prevent any additional attacks. For example, the President established the Office of Homeland

Security (OHS) with the mission to develop and coordinate the implementation of a comprehensive national strategy for terrorist attacks within the US (Monterey Institute of International Studies 2001). The mission statement for the OHS makes available any military equipment and personnel necessary to prevent, protect against, and respond to threats to the territorial US (Monterey Institute of International Studies 2001). The DOD, therefore, will have to place new emphasis upon counterterrorism training across federal, state, and local first responders, drawing on the capabilities of the Reserve and National Guard.

The Research Question

One of the main objectives for this study is to attempt to explore and emphasize a less discussed and perhaps foreseeable future WMD asymmetrical battlefield threat. To accomplish this objective, this thesis addresses the following question: Do TICs pose a WMD threat, and what are their effects on military joint doctrine for operations in chemical environments?

Subordinate Questions

The central research question gives rise to four subordinate questions that further define the nature and scope for this study: What is the military joint doctrine for operations in chemical environments? What is a WMD threat? What are CW agents? What are TICs and are they a threat? Answering these questions establishes historical and theoretical foundational framework into the discussion about WMD and TIC effect on military joint doctrine for operations in chemical environments.

Assumptions

This study proceeds under two assumptions: TICs are CW agents and TIC, TIM, and toxic industrial hazard (TIH) are synonymous. Toxic industrial chemicals are CW agents with toxicity at low levels, and used across the operational spectrum from the deployment of forces to posthostility activities. Given the velocity of recent terrorist events in the US, this assumption appears reasonable. Another reinforcement to this assumption is the idea that CW agents are particularly horrifying because their toxic effects are indiscriminate and thus affect not only military personnel but also the civilian population as a whole. Additionally, there is the possibility that these agents could provide a substantial psychological edge to a militant-developing country. For example, a weak or developing country might see the use of CW agents as an inexpensive alternative for maintaining regional security for or drawing recognition to a religious or political cause.

The potential is also there for US forces to operate in regions where new and different threats from WMD exist. Lessons learned from the Gulf War of 1991 increased awareness about the low level toxicity of chemical weapon agents. Coupled with those lessons learned is the reality of the recent terrorists' acts, making it imperative to train and equip US forces to function in the contemporary operational environment. Furthermore, this first assumption could be seen as taking steps to follow the current direction for the DOD, as cited in the latest *Quadrennial Defense Review*: "Adopting . . . capabilities-based approach to planning requires that the nation maintain its military advantages in key areas while it develops new areas of military advantage and denies asymmetric advantages to adversaries" (US Department of Defense 2001).

The second assumption is that TIC, TIM, and TIH are synonymous. However, in Joint Publication 3-11, *Joint Doctrine for Operations in Nuclear, Biological, and Chemical Environment*, it appears that TICs are a subset of TIMs. Nevertheless, for the purpose of this paper, the author assumes that they may be treated in the same manner for defensive planning purposes. Therefore, they are synonymous, and a definition is depicted in the following section. These words represent the terminology used by the different private and public agencies, to facilitate acquisition of emergency information concerning health and physical hazards, physical properties, handling procedures, and protection needs relative to hazardous industrial chemicals encountered during an event. Nevertheless, they all deal with the toxicity of CW agents at low levels and with the effects on humans, animals, and plants.

Definitions

This thesis deals with a number of concepts that require definition to ensure clarity of understanding. Some may be familiar to military and associated readers. Many reflect widely accepted terminology, but some do not. Additional definitions will be provided, as unfamiliar words appear within the thesis.

Asymmetric Warfare. It has been around for centuries (Allen 1997; Grange 2000). For example, the US Army's FM 3-0, *Operations*, June 2001, contains some very important sections relating to asymmetric warfare. It is a term used to refer to a range of actions that may include terrorism, cyberwarfare, or other unconventional responses to a technologically superior military power enjoying the advantage. In essence, it is a means for inferior militaries to gain advantage over mightier opponents. The bottom line is that asymmetric warfare encompasses anything (e.g., strategy, tactics, weapons, and personnel) that alters the battlefield to negate one side or the other's advantages.

Some examples may be instructive. The North Vietnamese took advantage of "the United States' lack of will to win" (Grange 2000). The kind of asymmetric strategy and tactics seen in the Vietnam War were termed "guerilla warfare" (Grange 2000). A recent example of asymmetric warfare is the riots, planned by faction leaders, made up of coerced noncombatants, and manipulated by gangster police, were effective against North Atlantic Treaty Organization (NATO) troops keeping the peace in Bosnia. Consequently, Slobodan Milosevic, chief of the Serbian Communist Party, was able to move special police troops and other thugs at will throughout Kosovo, destroying life and infrastructure, while NATO's unmatched airpower was incapable of stopping him.

As these examples show, asymmetric warfare is using something extraordinary or never before seen to gain advantage over mightier opponents. There are many other examples of tactical asymmetric applications that give advantage to less-sophisticated foes: obscurants to "defeat laser-guided weapons; limited communications to thwart electronic sensors; human (noncombatant) shields to protect combatants; and fighting in urban areas where heavy forces are impractical," to name a few (Allen 1997).

Chemical Agent. This terminology is synonymous with "military chemical agent." It is a chemical compound intended for use in military operations to kill, seriously injure, or incapacitate through its physiological actions as cited in FM 3-14, *Nuclear, Biological, and Chemical Vulnerability Analysis* (US Army 1998a). This definition is also more specific than the one in JP 3-11, which simply defines it as "any toxic chemical intended for use in military operations" (US Joint Chiefs of Staff 2000). Colonel James Romano, Commander of the US Army Medical Research Institute of Chemical Defense, however, provides a definition in a recently published book on CW agents that is analogous to the use in this study. He defines CW agents as “chemicals that have immediate, direct toxic effects on humans, animals, and plants and possible long-term, adverse effects on human health” (Somani and Romano 2001).

The Military classification of CW agents may fall into one of the following areas: choking, blood, blister, or nerve agents. These agents are either lethal in their effects or incapacitating, depending upon the class of agent, the concentration, and the period of exposure (US Army 1998a). Presented in chapter 2 of this thesis is a more complete description of the CW agents.

<u>Chemical Weapon</u>. The JP 3-11 provides a lengthy three-part definition that requires reading it together or separately. As defined in JP 1-02, *DOD Dictionary of Military and Associated Terms* it is a toxic chemical and its precursors, munitions or device, and any equipment specifically designed for use directly in connection with the munitions or devices (US Joint Chiefs of Staff 2001a).

<u>Chemical Warfare (CW)</u>. All aspects of military operations involving the employment of lethal and incapacitating munitions or agent and the warning and protective measures associated with such offensive operations (US Joint Chiefs of Staff 2001a).

<u>Contemporary Operational Environment (COE)</u>. The definition for this relatively new terminology comes from the US Army’s Combat Maneuver Training Center and Training and Doctrine Command (TRADOC) (Warren and Lindstrom 2000). The TRADOC white paper identifies seven characteristics of future military operations;

however, the terrorist attacks in the US on 11 September 2001 demonstrate that the COE envisioned for the future is here now. Chapter 2 of this thesis provides a detailed explanation of each of the seven characteristics and the four common threads that are perhaps essential to the critical skills demanded of US Army leaders.

Briefly, the TRADOC white paper definition is that a COE is a composite of all the conditions, circumstances, and influences that affect the employment of military forces and bear on the decisions of the unit commander (Warren and Lindstrom 2000). In other words, the COE is the factors and variables that affect where soldiers will live, work, and fight.

Industrial Chemical. Chemicals developed or manufactured for use in industrial operations or research by industry, government, or academia. The manufacturing of these chemicals is not primarily for the purpose of producing human casualties or rendering equipment, facilities, or areas dangerous for human use (US Joint Chiefs of Staff 2001a). In Appendix 1 of this thesis is a chart that list the sixty industrial chemicals deemed to be of high-to-moderate risk of posing a chemical hazard in a military situation.

Nonstate Actors. Nonstate actors may come in various forms, but their defining feature is action outside the boundaries of established state authority. They may restrict their actions to the territory of a particular state, as in the case of an insurgency, or they could be transnational, for example terrorists, bridging states, and even regions (National Defense University 2001; Reichart 1998).

Rogue States. The research by the National Defense University's Center for Counterproliferation defines these types of states not based on their primary capability, but rather by their willingness to act routinely outside prevailing norms of state conduct.

The level of capabilities could vary widely, but the distinctive features of their conduct are risk-taking and unpredictability (National Defense University 2001; Reichart 1998). The following are frequently cited rogue states: Cuba, Libya, Iran, Iraq, North Korea, and Syria.

Toxic Chemical. Any chemical, which, through its chemical action on life processes, can cause death, temporary incapacitation, or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production and regardless of whether they are produced in facilities, munitions or elsewhere (US Joint Chiefs of Staff 2001a).

Toxic Industrial Chemical (TIC). Any chemical hazard that is toxic and/or lethal and that is not designed specifically for military purposes, however, may be employed as a CW agent (US Army 1998a). Although the acronym TIC is found in the JP 3-11's glossary for abbreviations and acronyms, it does not provide a specific definition for TIC. However, JP 1-02 does provide definitions for "industrial" and "toxic chemicals" that clearly defines the acronym TIC, when read together. Likewise, this thesis uses TIC in the same manner. Additionally, illustrated in Chapter II is a not all-inclusive chart representing examples of some common TIC.

Toxic Industrial Hazard (TIH). It is a liquid or a gas that is toxic to humans and poses a health hazard during transportation. The presumption is that it is toxic to humans because when tested on laboratory animals it has a lethal concentration of 50 (LCt50) (Stuempfle et al. 1998). Table 2 in this thesis provides a more detailed definition for the lethal concentration usage. This thesis defines LCt50 as the inhalation exposure at doses which produce lethality in 50 percent of any given population and, ECt50 as the inhalation exposure at doses causing a defined effect (e.g., incapacitation, severe effects, mild effects, threshold effects) in 50 percent of any given population. The research source for this data is the National Academy of Sciences Report done in 1994 by the Army's Chemical Defense Equipment Process Action Team (CDEPAT) (Augerson 2000). Additionally, the National Research Council’s (NRC) report shows that a majority of human toxicity estimates made by the Army in 1994 should be considered either as an interim value or be lowered (Augerson 2000).

Toxic Industrial Material (TIM). Any chemical substances with relatively high toxicity when inhaled, produced, stored, and transported in large volumes may pose a risk to friendly forces and noncombatants. FM 3-06.11, *Urban Operations*, provides a discussion about TIM, but it fails to cite a definition (2001b). FM 3-06.11 provides a list of the most common TIMs: chlorine, sulfur dioxide, ammonia, and hydrogen chloride (US Army 2001b). These most common types of TIMs are identical to the TICs in the *International Task Force 25 Hazard from Industrial Chemicals, Final Report*t, cited in Appendix 1 of this thesis (Stuempfle et al. 1998).

Weapon of Mass Destruction (WMD). WMDs are capable of a high order of destruction, used in such a manner as to destroy large numbers of people. They can include NBC and radiological weapons, but exclude the means of transporting or propelling the weapon where, such means is a separable and divisible part of the weapon (US Joint Chiefs of Staff 2000 and 2001a; US Army 1998a). In order to be consistent with the most commonly used terminology, this study uses the term WMD to refer to CBRNEs.

Limitations

While this thesis is broad in scope and addresses many issues relevant to the subject of TIC, it is not all encompassing. There are several limitations to the range of this thesis, given its audience, objective, and scope. One limitation for this thesis is the lack of published writings on the topic with specific regard to a military perspective or scenario. Most of the written literature is not from the military community; but from private corporations, governmental, and nongovernmental agencies. Consequently, their descriptions are subjective in nature; however, their theories represent the best insight into applying and analyzing future war-fighting, geopolitical, and social considerations in regards to TIC.

Despite the proliferation of WMD, the concept of TIC is still in a developing stage. Doctrine concerning TIC within the US Army Chemical Corps and perhaps throughout DOD is still evolving. For example, terminology and definitions are, in some cases, changing from year to year, or are different between agencies, and in some instances are not included within an organization's list of definitions or vocabulary. Nevertheless, this thesis will indicate those differences throughout the course of the review.

Delimitations

The thesis focuses on passive defense and its role in protecting US forces in an NBC situation in a COE. While not excluding the need to protect allied, coalition, and noncombatants, these issues are beyond the scope of this thesis. Granted the definition of WMD includes CBRNE, this thesis concentrates on the threat posed by low level toxicology of CW agents, which this study classifies as synonymous with TIC.

Consequently, it is not the intent of this study to prescribe needed passive defense requirements in terms of equipment, but rather capabilities.

Additionally, this study recognizes that future technological and environmental assessments do not fully lend themselves to describing a complete list of needed requirements for TIC. In those instances, the baseline and an assessment of current capacity to support that requirement will be the most common and accepted institutional requirements. Additionally, to allow for a wide dissemination, this study will use documentation available through unclassified sources. Finally, to ensure this study maintains its relevancy and accuracy, the majority of the material considered will be limited to that available for public disclosure through 2001.

Significance of the Study

Saudi Arabia during both Desert Shield and Desert Storm was an environment in which there was a significant threat for the use of CBW. The troops were very aware of the chemical and biological threat and were nervous about it. Iraq had developed several types of chemical weapons and had previously used sulfur mustard (HD) a blister agent and nerve agent in the war with Iran. Iraq had publicly threatened the use of chemical weapons in the Gulf War and is believed to have an active program developing biological weapons (in particular anthrax). Tension and anticipation resulted in clusters of alarms and warnings, anecdotal stories, and rumors concentrated in the periods in which the tempo of the war increased.

The author intends to contribute to the body of knowledge necessary to combat the threats discussed in this thesis. Clearly, the threat to national security posed by unfriendly entities, undeterred by threats of retaliation, wielding WMD and possessing the will to use them for political, economic, or religious reasons represents a clear and present danger to the US. This study, by further defining toxic industrial chemicals (TICs) will illustrate that TICs, even with an acute toxicity level, pose a foreseeable future WMD threat. While understanding the motivation behind the use or acquisition of these capabilities, it is essential to take this understanding to the next level by thinking through the range of plausible uses of TIC. Only by doing so can one begin to appreciate how best to deter their use, or failing that, be capable of defending against their use and operating effectively in a COE.

Whether health effects caused by chemical exposures during a deployment are immediate or delayed (even delayed for several years), the risk of *any* adverse health effect is to be considered in military operations. The relevance of the topic is clear. There are two running arguments about TIC or low level toxicity CW agents. One argument is that often, the lethality of TIC can be greater than those traditionally considered CW agents. The second argument is that TICs are not CW agents because they are so much less toxic and often have colors and or odors that warn the personnel before the toxic fumes can hurt them.

This second argument is not, true and it perhaps justifies the need for this thesis. The focus when it comes to CW agents certainly should not rely solely on the toxicity level, but other factors as well--effects. While the risks posed by low level chemical agents may be perceived as minimal or nonexistent, DOD has accepted that there may be situations where such risks must be incorporated into operational risk management decisions FM 100-14, *Risk Management* (US Army 1998b). However, there is a lack of consensus on a definition of “low level” within DOD and throughout the scientific community.

An essential reason that such information is lacking is the basic means by which most toxicology research is conducted. For example, exposure of experimental animals to toxic agents in high doses is a necessary and valid method of discovering possible hazards in humans (Somani and Romano 2001). Obtaining statistically valid results from small groups of animals requires the use of relatively large doses, so that the effect will occur frequently enough to be detected and studied. For example, an incidence of a serious toxic effect as low as 0.1 percent would represent 2,000 people in a population of 2 million (Somani and Romano 2001). Detecting this low incidence in experimental animals directly would require a minimum of 30,000 animals (Somani and Romano 2001). For this reason, large does are administered to relatively small groups, and then toxicological principles are used to extrapolate the results to estimate the risk at low levels. Consequently, complications or errors may be introduced when testing interactions of low levels of CW agents with other chemicals if the low level effects for these other chemicals are based on extrapolation from high-level effects.

Nevertheless, after the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999: CW Defense, the DOD developed a strategy to yield data that would guide the potential evolution of policy and doctrine on exposures to CW agents (Public Law 105-261 1998). The principal objective of the strategy is to generate knowledge required for assessments of CW agents and associated battlefield hazards. Consequently, DOD drafted a Report to address the objectives laid out in Public Law 105-261 (US Department of Defense 1999). The report outlines the efforts underway within the department to develop and carry out a plan to establish a research program for determining the effects of chronic and low-dose exposures to CW agents.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews current literature about the topic of TICs from a CW agent perspective. Although low in toxicity levels, TICs are CW agents, but few connect them to a WMD threat. There are countless books, periodicals, government documents, and Internet materials dealing with the threat associated with CW agents toxicity at low levels and many more on the threats posed by terrorist groups. Many of the sources provide bibliographies comprised of several pages of references and most address several areas relevant to this thesis. Consequently, this study uses those materials to provide the historical and theoretical framework for this topic.

CW Agents Background

CW agents are perhaps among the easiest WMD to produce and transport via trains, planes, or boats. The lethality of chemical agents falls generally between that of the biological agents and that of conventional weapons. As cited by several authors, the earliest chemical agents first used in World War I were far less sophisticated and far less lethal than those developed in subsequent decades (Cookson 1969; Stockholm International Peace Research Institute 1971 and 1973; Heller 1984; and Spiers 1994). Basically, modern CW began with the extensive use of chemical agents during World War I, initially with the German use of industrial chemicals, such as chlorine and phosgene, and later uses of agents tailored for military use, such as the mustards (Cookson 1969; Heller 1984; and Spiers 1994).

The history of modern military toxicology can be traced to the World War I, when 100,000 Allied soldiers were killed and one million wounded by poisonous gas

(Stockholm International Peace Research Institute 1980). According to Augerson, although the use was modest, “Japan used chemical weapons against China early in World War II” (Augerson 2000). Additionally, a number of sources indicated that research and development activities were competitively intense during those wars (e.g., Germany would develop agents and other countries would do the same) (Cookson 1969; Stockholm International Peace Research Institute 1971, 1973, and 1980; Heller 1984; Spiers 1994; and Augerson 2000). The vast arsenal of chemicals developed during World War II brought with it new toxicological issues as soldiers were exposed to increasingly complex chemical mixtures during the routine operation and maintenance of their machinery and in some climates, “to the protective agents designed to combat disease-carrying insects and pathogens” (Stockholm International Peace Research Institute 1971, 1973, and 1980).

At the same time, the incredible growth of the US munitions industry brought to light the importance of industrial environmental toxicology. After thousands were killed or injured due to exposure to Trinitrotoluene (TNT) and nitrous gases in US munitions plants, it was impossible to deny the critical importance of understanding industrial as well as warfare toxicants (National Research Council 1997). Since then, the continued development of CW agents worldwide, as well as their demilitarization, has created a growing operational concern for exposure to these agents not only in wartime activities, but also from potential terrorist activities.

A few years after the end of World War II, Dr. Ranajiit Ghnosh of England synthesized a nerve agent that was much more potent than sarin (Somani and Romano 2001). Additionally, in the declining days of the Cold War, some regional powers, such as Iraq, Iran, and Libya, developed and employed chemical weapons (Cheny and Harvey 1986; Lewis and Johnson 1995; Reichart 1998; Joseph 1996; and Augerson 2000). Among the nerve agents, sarin is one of the CW agents that dates back to World War II (Augerson 2000). A recent use of sarin was during the Iran and Iraq conflict, and there was an alleged usage during the Gulf War (US General Accounting Office 1998b). The most recent are two different terrorist attacks involving sarin gas in Japan (US General Accounting Office 1988a). These recent episodes attracted the world's attention about the threat to the general world population and added new dimensions to the dangers that humanity is facing all over the globe.

Although a few chemical agents, such as phosgene, chlorine, and phosgene oxime, may degrade materials (i.e., corroding metals, degrading rubber), CW agents, when used, are primarily directed at humans and other living organisms (US Army 1990; Sidell 1997; and Somani and Romano 2000). History has shown that chemical weapons are capable of use across a wide spectrum of warfare, from acts of assassination and small-scale terrorism to various tactical and operational situations, both defensive and offensive, including strategic population attacks. It is also well recognized that the technical and economic barriers to development and weaponization have decreased, and many CW agents, particularly choking, blood, and blister agents, are relatively easy to produce (Lewis and Johnson 1995; Tucker 1996; US General Accounting Office Report 1998a; Joseph and Reichart 1999; and Peters 1999).

Types of CW Agents

Traditionally, US Armed Forces classify CW agents into four classes of CW agents: (1) choking (e.g., phosgene and chlorine, and both used simultaneously during

World War I); (2) blood (e.g., cyanide); (3) blister (e.g., sulfur mustard); and (4) nerve agents (e.g., sarin) (US Army 1990; 1994; and 1998). These agents differ in terms of their rapidity of action, lethality, and the requirement for prompt and or sustained medical care. Table 1 provides a brief description of the four classes of agents.

Choking agents are the oldest CW agents. This class includes chlorine and phosgene, first used in World War I. These agents have a corrosive effect on the respiratory system that causes the lungs to fill with water and choke the victim. These agents are usually delivered as heavy gases that remain near ground level and tend to fill depressions. They dissipate rapidly in a breeze and are among the least effective traditional CW agents.
Blood agents are absorbed into the body primarily by breathing; they prevent the normal utilization of oxygen by the cells causing rapid damage to body tissues. This class includes hydrogen cyanide (hydrocyanic acid, AC) and cyanogen chloride (CK). They are highly volatile and in a gaseous state dissipate rapidly in air.
Blister agents typically used to cause medical casualties; they affect the eyes and lungs and blister the skin. Such agents are simple to produce, and include sulfur mustard (HD), nitrogen mustard, and Lewisite (L). Sulfur mustard considered by some as the ideal CW agent. Presents both respiratory and percutaneous hazards, forcing personnel to wear masks and protective clothing. It is persistent and presents a long-term hazard, forcing decontamination of the battlefield.
G-series nerve agents, developed in the 1930s, cause paralysis of the respiratory musculature and subsequent death, in sufficient concentration. They include tabun (GA), sarin (GB), soman (GD), and cyclosarin (GF). These agents act rapidly and may be absorbed through the skin or the respiratory tract. Some agents, such as GA and GB, tend to be relatively nonpersistent, creating a short-term respiratory hazard on the battlefield.
V-series nerve agents, developed in the 1950s, are similar to, but more advanced than, G-series agents. This class includes VE, VG, VM, VS, and VX. These agents are more toxic and more persistent than the G-agents and present a greater percutaneous hazard, and used for long-term contamination of territory.

Table 1. Types of Chemical Warfare Agents
Source: US Army 1990; 1994; and 1998.

Many CW agents, particularly choking, blood, and blister agents, are relatively easy to produce. Some of their technologies are more than eighty years old, making them accessible by virtually any Third World country and many terrorist groups. Newer agents, particularly nerve agents, are somewhat more difficult to produce. However, much of the technology to produce these agents is widely available in the public domain, as illustrated by the example cited earlier in the 1995 terrorist act in Japan.

Various CW agents can be irritating and incapacitating and can injure or kill. Some agents cause only local effects, and some have only systemic effects, while others have both effects. An irritating or incapacitating agent could cause a retreat or render persons unable to advance allowing a terrorist time to accomplish their goal. Some chemicals may evaporate quickly while others may remain for long periods. This description is their persistency. Persistence can be from minutes to days and this determination comes from the chemistry of the agent and the environment.

Chemical agents can be in the form of solids, powders, liquids, or gases. Agents may be inhaled or swallowed or enter the body through eyes or skin, and their effects can be immediate or delayed. Table 2 defines the dose and exposure characterizations associated with these CW agents.

Cutaneous (skin) exposures expressed in terms of a total dose or the weight of the agent (milligrams or micrograms) per square centimeter times the total area exposed. **LD_{50}** represents the lethal dose (LD) that produces 50% mortality in the exposed population. **ID_{50}** represents the incapacitating dose (ID) that incapacitates 50% of the population.
Respiratory exposures expressed in terms of the product of the concentration (C) of the vapor or aerosol, usually expressed as milligrams or micrograms per cubic meter or liter, and the length of the exposure (T). Consequently, the resulting value is known as the CT. **LCt_{50}** is the CT required to produce 50% mortality in the exposed population. **ICT_{50}** is the CT required to incapacitate 50% of the exposed population.

Table 2. Dose and Exposure Characterization
Source: US Army 1990; 1994; and 1998.

Table 3 provides a summary of the typical CW agents of concern, including their historical lethality, principal target tissue, and principal behavioral effects of the CW agents.

Class of CW Agent	Historic Lethality in Warfare	Principal Target Tissue	Physiological Performance Effects
Choking (e.g., phosgene [CG])	1%[a]	Deep lung compartment such as pulmonary capillary	Pulmonary edema, hypoxia
Blood (e.g., hydrogen cyanide [AC])	Unknown[b]	Cellular respiratory enzymes	Depression of cortical function, unconsciousness, convulsions
Blister (e.g., sulfur mustard [HD])	2 - 4[c]	Skin, airway, eyes, Gastrointestinal (GI) tract, bone marrow	Loss of function due to skin, lung, ocular lesions, recovery over time
Nerve (e.g., sarin [GB])	Unknown[d]	Central nervous system (CNS), neuromuscular junction; cholinergic synapse	Gastrointestinal (GI) tract, miosis, nausea, weakness, loss of consciousness, convulsions

[a]World War I figures for the US are estimates because phosgene was often mixed with chlorine; however, 6834 injured (average hospitalization = 49 days) have been directly attributed to phosgene with 66 fatalities.

[b]No data from wartime use; however, wartime experiences suggest difficulty in achieving militarily effective concentrations unless confined to closed spaces.

[c]World War I, 2 percent with 27,711 US injured; Iran-Iraq War, 4 percent with 45,000 estimated injured.

[d]No data from wartime use; however, on 20 March 1995, using a primitive method of dispersal, sarin was released on Tokyo subway with 5,500 people seeking medical care; approximately 1500 had defined symptoms of exposure, and 12 casualties died. Less well known is the fact that on 27 June 1999, there was a release of sarin in Matsumoto, Japan, and with estimates of 471 subjects exposed to sarin and seven deaths.

Table 3. Lethality of Four Classes of CW Agents and Their Principal Target Tissues
Source: Somani and Romano 2001 p. 398

This information on CW agents is provided to establish the CW agents' linkage to TIC and make the case that TIC are and can be used as a WMD in the future. Military CW agents often contain stabilizing chemicals that have their own toxicity, but most laboratory research on agent effects is done with chemicals purer than weapon-grade material and thus may not predict all effects of chemical weapons (US Department of the Army 1982 and 1985; and US Army 1990). Consequently, the objectives of use can affect agent selection, from creating defensive barriers that deny entry to territory and facilities using persistent agents, to supporting attacks with highly toxic but nonpersistent agents.

According to numerous DOD sources (regulations and field and technical manuals) CW agents are classified as "persistent" or "nonpersistent." Persistent agents include the vesicants, such as sulfur mustard (HD) and Lewisite (L) and the nerve agent (VX) (US Army 1990; 1994; and 1998a). Nonpersistent agents are more volatile and do not remain in an open environment for more than a few hours. Among these are phosgene, cyanide, and the nerve agents, tabun (GA), sarin (GB, soman (GD), and cyclosarin (GF) (US Army 1990; 1994; and 1998a). A more detailed discussion of the CW agents: nerve, blister, blood, and choking CW follows.

Nerve Agents

There is a great deal of literature on nerve agents, including several recent books on chemical agents (Sidell et al.1997; Augerson 2000; and Somani and Romano 2001). The military nerve agents are a family of highly toxic phosphoric acid esters, and exert their effects by inhibition of the enzyme acetylcholinesterase (AchE) (Sidell et al. 1997; and Somani and Romano 2001). This enzyme inhibition is both rapid and irreversible, thus making nerve agents highly toxic and extremely dangerous chemicals (see tables 3 and 4). The design of these agents was to kill or incapacitate enemy forces, disrupt military operations, and deny terrain to the adversary. In unscrupulous hands, recent history reveals that nerve agents are effective weapons of terror.

Symptom	**War and Illness**					
	US Civil War DaCosta Syndrome	World War I	World War II Combat Stress Reaction	Vietnam Agent Orange Exposure	Vietnam Post-Traumatic Stress	Persian Gulf Unexplained Illness
Fatigue and exhaustion	+	+	+	+	+	+
Shortness of breath	+	+	+		+	+
Palpitations and tachycardia	+	+	+		+	
Precordial pain	+	+			+	+
Headache	+	+	+	+	+	+
Muscle or joint pain				+	+	+
Diarrhea	+		+	+	+	+
Excessive sweating	+	+	+			
Dizziness	+	+	+	+	+	
Fainting	+	+				
Disturbed sleep		+	+	+	+	+
Forgetfulness		+	+	+	+	+
Difficulty concentrating		+	+	+	+	+
Note: A plus (+) sign indicates a commonly reported symptom						

Table 4. Somatic Symptoms Commonly Associated with War-Related Illnesses
Source: Somani and Romano 2001, p. 263.

The first nerve agent of military significance was discovered in 1937 by Dr. Gerhard Schrader, a chemist conducting insecticide research with organophosphates (Stockholm International Peace Research Institute 1971 and 1973). Doctor Schrader synthesized ethyl-N-dimethyl-phosphoroamidocyanate, commonly referred to as tabun. The investigator personally experienced the toxicity when he found that a small drop of tabun, spilled on a laboratory bench, resulted in pinpoint pupils, dim visions (i.e., ability to see), headache, and difficulty breathing (Stockholm International Peace Research Institute 1971 and 1973). This initial research of Dr. Schrader was a springboard to the development of other related nerve agents, such as sarin and soman.

The designation "G" that now appears on the military nerve agents arose from the markings on German chemical weapons found after the war: GA for tabun, GB for sarin, and GD for soman (Stockholm International Peace Research Institute 1971). Several G agents varied in the threat they posed via the skin (sarin was not very effective), and efforts were made to mix them with other agents that might enhance skin penetration, such as mustards or Lewisite (Stockholm International Peace Research Institute 1973).

Blister Agents

Several mustards (H, HD), Lewisite (L), and phosgene oxime (CX) all fall into this class of blister agents (i.e., vesicants or skin damaging). The amount of research information is not the same for these agents, with little information available on phosgene oxime and only small amounts on the others from the 1960s and 1970s. However, there is a large body of literature on the biochemical interactions of mustards. Augerson believes this occurred in part by scientists' interest in mustard agents' application to cancer chemotherapy, and because of concerns about civilian exposure risks from demilitarization efforts (Augerson 2000).

Nevertheless, each of these blister agents have quite different chemistries and mechanisms of action, but all are capable of eye damage at low levels, pulmonary injury at any level, and notable systemic effects at higher doses (Stockholm International Peace Research Institute 1971 and 1973; and Sidell et al.1997). These agents vary greatly in the timing of the onset of clinical signs and symptoms: immediately for phosgene oxime, promptly for Lewisite (seconds to minutes), and delayed (hours) for mustards (Franke 1967; and Stockholm International Peace Research Institute 1971 and 1973).

Phosgene oxime is known as “nettle gas,” so named because of its property of intensely irritating the skin immediately after contact (Franke 1967; and Stockholm International Peace Research Institute 1971 and 1973). In Franke’s *Manual of Military Chemistry*, he cited that phosgene oxime’s symptoms spread far beyond the region of initial exposure. Major powers stockpiled this agent during World War II, although there is no record of its use (Stockholm International Peace Research Institute 1971 and 1973). There were indications of Iraqi use of an agent whose effects resembled phosgene oxime against Iran, but confirmation is lacking, and Lewisite was suspected, too (US General Accounting Office 1998b).

According to Franke, “Lewisite is relatively simple and inexpensive to produce, making it attractive to less advanced nations beginning CW programs” (Franke 1967). Lewisite acts promptly on exposure, persists with moderate potency, and mixes easily with other chemical agents to augment toxic effects (e.g., HL a mustard-Lewisite mixture). According to the *Textbook of Military Medicine*, Lewisite is a significant threat to unprotected personnel for that reason (Sidell et al. 1997). Additionally, it causes prompt incapacitation from eye injuries and respiratory irritation, coupled with long-term incapacitation from skin burns, pulmonary injury, and systemic illness (Sidell et al. 1997; US Army 1990).

Choking Agents

The use of choking agents occurred on the battlefield early in World War I. Several of these agents (e.g., phosgene and chlorine) produced a large number of casualties requiring extensive hospitalization (Franke 1967; Sidell et al. 1997). Phosgene is a simple, highly volatile molecule known as carbonyl chloride, that upon inhalation, chemically induces acute lung injury because of a reaction of it carbonyl group with groups affecting cell membrane stability (Franke 1967; Sidell et al. 1997). The primary clinical effect of phosgene is a pulmonary edema following a clinical latent period of variable length that depends primarily on the intensity of exposure (Franke 1967; US Army 1990).

Blood Agents

The common blood agents are hydrogen cyanide (chemical formula HCN or CW symbol AC) and cyanogen chloride (chemical formula CCIN or CW symbol CK). Hydrogen cyanide has a rapidly acting lethal agent that causes death within six to eight minutes after inhalation of a high concentration (Moore and Gates 1946). Blood agents appeared on the World War I battlefields within weeks after the initial use of choking agents and were employed in an effort to produce rapidly lethal casualties (Franke 1967; Sidell et al. 1997). However, no studies or casualty figures exist to suggest that cyanide is effective in producing militarily significant casualty rates in a trained and protected force. Nevertheless, there is the argument that these agents remain a threat to armed forces and civilians in both conventional and unconventional conflicts.

Chemical Warfare Agents Means of Action

CW agents are either lethal in their effects or incapacitating, depending upon the class of agent, the concentration, and the period of exposure. The designs of most CW agents are volatile, nonpersistent and encountered as vapor or gas (Sidell et al. 1997; Augerson 2000). The persistence of agents dispersed as solids, liquids, aerosols, or vapor, is dependent on factors, such as temperature, pressure, and wind speed (US Army 1990; 1994; and 1998a). In addition to CW agents' toxicities, their chemical structures are simple, and the manufacturing processes for most are relatively uncomplicated and inexpensive. Basically, CW agents represent significant hazards because they are manufactured in large quantities for use in industry and shipped in bulk by truck, train, boat, or plane (Tucker 1996; Hughart 1998; Stuempfle 1998; and US Army 1998a).

One of the significant hazards is the contamination of foods by CW agents. The effects of chemical agents on food depend on the nature of the agent, as well as the nature of the food. For example, foods having a low water content and a high fat content such as butter, oils, fatty meats, and fish absorb agents so readily that removal of the agents is virtually impossible (US Army National Research Council 1982 and 1985). The previously cited sources also concluded that unprotected foods could become highly toxic without changing the appearance of the food. Protected foods, however, in cans and bottles or food wrapped in heavy plastic are not affected by agent vapor and can be salvaged following decontamination.

Another significant hazard is the environmental factors that affect community and individual well being more than the ready availability of adequate and safe potable water. For example, surface water sources in the area of a chemical release could become contaminated, and the contamination of water, whether intentional or inadvertent, may reach concentrations that could produce casualties. However, deep ground water reservoirs and protected water storage tanks are safe sources of drinking water following a vapor release of chemical agents (Moore 1989). While avoiding any possibly contaminated water source should be a goal, methods such as reverse osmosis are available to treat large volumes of potentially contaminated water for emergency drinking. However, some sources concluded that these techniques may not eliminate low-dose exposure to the contaminating agent (Jane's International Police Issues 1998a; Moore 1989).

Issues Related to Low-Dose Exposure to Chemical Agents

There is a rapidly increasing interest in the low level toxicology of CW agents. The National Institutes of Health, the Centers for Disease control in Atlanta, the Veterans' Affairs Department, and the US Army have a tremendous interest in this area, again stimulated by the aftermath of the Persian Gulf War. This concern regarding a high incidence of undiagnosed illness among Gulf War veterans, led to the Office of Special Assistant for Gulf War Illnesses (OSAGWI), a Presidential Advisory Committee to analyze the Federal Government's outreach, medical care, research and coordinating activities pertinent to Gulf War Illnesses (GWI).

The effects of exposure to low doses of CW agents have been of considerable interest for several decades. For example, a large portion of the written literature cites the period of large-scale production of CW agents in the US and concludes that this subject was a particularly important occupational health issue for workers in production plants (Stuempfle et al. 1998). Stuempfle and others refer to the fact that new attention to this issue came about when the results of human testing involving chemical agents, conducted by the US Army, was the topic of the National Research Council reports (National Research Council 1982 and 1985).

A second group of writings concluded that this issue peaked again when the risk assessment and public health programs responded to the chemical demilitarization of the stockpiles of these same weapons (Stockholm International Peace Research Institute 1980; Hughart 1998). Thus, several panels of experts reviewed these Gulf War Illnesses extensively and cited in a myriad of published sources that soldiers received low level CW agent exposure during their period of service in the Persian Gulf. This issue of CW agents at low levels remains (i.e., TIC) critical and is of significant importance today in the force protection and first responders missions. Taking a closer look into the Persian Gulf War may provide the credible case as to whether TICs are WMD.

Persian Gulf War Illnesses

Ten years following the Persian Gulf War, uncertainty remains regarding potential exposures, health risks, and adverse outcomes in the US troops deployed to Operations Desert Shield and Desert Storm. This was not the first military armed conflict to report medically unexplained symptoms, as Somani and Romano clearly illustrated. An example of these types of complaints dates back to the Civil War. Somani and Romano grouped them into two general categories of war-related illness: a poorly understood group thought to be associated with physiological disease, and another group of psychological illnesses attributed to wartime stress (Somani and Romano 2001). These complaints are depicted in table 4 on page twenty-seven of this thesis.

Between August 1990 and March 1991, the United States deployed a total of 697,000 troops to the Persian Gulf during Operations Desert Shield and Desert Storm. Throughout this massive deployment, there was substantial concern that infectious diseases that are endemic in this area of the world could threaten the health of coalition troops (Gasser et al. 1991, 859). Based on experience with infectious diseases among military personnel during World War II, foreign troops stationed in the Persian Gulf expected to be at especially high risk of shigellosis, malaria, sandfly fever, and cutaneous leishmaniasis (Quin 1992). Studies conducted since the war with Iraq have provided a better understanding of the threat of infectious diseases in the Persian Gulf.

To further explore this hypothesis, the DOD Comprehensive Clinical Evaluation Program (CCEP) in 1994 analyzed findings in military personnel who had health concerns after service in Operation Desert Shield and Desert Storm (Kroenke et al. 1998). Among 18,495 patients examined, symptom onset was often delayed, with two-thirds of symptoms not developing until after individuals returned from the Gulf War and 40 percent of symptoms having a latency period exceeding one year (Kroenke et al. 1998).

Kroenke, Koslowe, and Roy analyzed the exposures to various factors that registrants in the DOD's CCEP reported. Table 5 shows the overall symptoms frequency for the CCEP recorded data on the evaluated veterans. Although the reports lack validation, 1,145 soldiers thought they received exposures to nerve agents, and 422 soldiers reported exposures to mustards. The authors concluded "prolonged latency of symptom onset and the lack of association with any self-reported exposures makes illnesses in Gulf War veterans related to toxic exposure less likely" (Kroenke et al. 1998).

Symptom	Any Complaint (%)	Chief Complaint (%)
Joint pain	50.0	12.1
Fatigue	46.9	10.6
Headache	39.7	7.9
Memory / fatigue problems	34.0	4.1
Sleep disturbance	33.0	2.7
Rash	30.2	6.3
Concentration difficulty	26.4	.5
Depressed mood	22.3	1.0
Muscle pain	21.2	1.1
Dyspnea	18.4	2.7
Diarrhea	18.2	1.8
Abdominal pain	16.3	1.6
Hair loss	11.8	0.5
Bleeding gums	8.2	0.1
Weight loss	6.4	0.1

Table 5. Gulf War Veterans Symptom Frequency
Source: Kroenke et al. 1998 as compiled in 1994.

A prominent theme in many Gulf War discussions is the speculation that some veteran illnesses may result from the combined effects of several drugs and chemicals. Although there has been disagreement about design and conclusions of a hypothesis, there is perhaps some experimental support for these concerns. The most recent interest in this subject has been generated as a result of “Gulf War Syndrome,” (GWS) which is a term used to describe the illnesses, many Gulf War (1990-1991) veterans reported. Clinical signs included: “rashes, fatigue, muscle and joint pain, headaches, loss of memory, depression, abdominal pain and diarrhea, coughing, sneezing, choking sensations, chest pain, sleep disturbance, and hair loss” (Nicolson et al. 2001). The previous references also suggested that the cause for this malady was the exposure of soldiers to low levels of CW agents during their period of service in the Persian Gulf.

The GWS and Gulf War Illnesses (GWI) are terms used to describe a collection of chronic signs and symptoms reported by several countries (Nicolson et al. 2001; US General Accounting Office 1998b). As depicted in table 6, the Persian Gulf veterans' exposures were to a wide array of known and potential hazards to health.

EXPOSURE	AVAILABLE DATA
Infectious Diseases	Case reports and summaries
Pyridostigmine Bromide	No centralized record of recipients Toxicological studies of effects Toxicological studies of interactions
Immunizations	No centralized database of recipients
Pesticides	Amount shipped to theater
Chemical Agent Resistant Coating Paint	No industrial hygiene monitoring data
Depleted Uranium	Clinical follow-up of soldiers with imbedded shrapnel Health risk assessment in progress based on modern exposures
Petroleum Products	No industrial hygiene monitoring data
Oil-Well Fires	Human Health Risk Assessment based on monitoring data
Biological Warfare Agents	No data
CW Agents	Modeled data based on Khamisayah, Iraq

Table 6. Exposures of Interest in the Gulf War and Availability of Exposure Data
Source: Somani and Romano, 2001, p. 277.

The risk factors included the following: extremes of heat and cold, blowing dust, smoke from oil well fires, petroleum fuels and their combustion products, pyridostigmine bromide (administered as pretreatment for potential poison gas exposure), anthrax and botulinum toxoid vaccines, depleted uranium, infectious diseases, CW agents, pesticides, and pervasive psychological and physical stress (Haley et al. 1997).

Five years after Operation Desert Storm in 1991, an estimated 5,000 to 8,000 of the approximately 700,000 Gulf War veterans remain ill with vague symptoms that resemble chronic fatigue syndrome (Gasser et al. 1991, 860; Quin 1992). The localization for these symptoms are not to any one organ, and the signs and symptoms and results from routine laboratory tests are not consistent with a single, specific disease. However, professors from the Institute for Molecular Medicine concluded that GWI is due to accumulated toxic exposures that can result in chronic illnesses with relatively nonspecific or nonunique signs and symptoms (Nicolson et al. 1998). These authors also concluded that for the most part, patients do not appear to have some new syndrome; they can be best described as patients with Chronic Fatigue Syndrome, Fibromyalgia Syndrome or Multiple Chemical Sensitivity Syndrome.

Although the GWI usually do not result in death, there are now thousands of U. S. Desert Storm veterans dead from a variety of illnesses that may have been obtained from their service (Nicolson et al. 1998). Doctor Nicolson testified before the US Senate that "the possible reasons why these deaths have not been reported in official studies of the problem could be due to the limited sizes of study groups and time intervals used for analysis, the lack of information on veterans who have left the Armed Forces, and the primary use of military hospitals for the analysis" (Nicolson et al. 1998). Whether health effects caused by chemical exposures during a deployment are immediate or delayed (even delayed for several years), the risk of any adverse health effect is to be considered in military operations. Therefore, the lessons learned from the Persian Gulf War are clear and perhaps TICs are WMD.

Possible Chemical Warfare Exposure

Before the Desert Shield and Storm, Iraq had made extensive use of CW against Iran and its own people (US General Accounting Office 1993). In addition to Iraq, six other countries conducted a program of research and development of chemical and biological weapons (see table 7). This capability caused concern for the US and coalition forces. However, during the air war and the short ground war, there were no obvious chemical or biological attacks on coalition forces (US General Accounting Office 1993).

State Supporters	Nuclear Program	Chemical Weapon Program[1]	Biological Weapon Program
Cuba	None	None	Confirmed
Iraq	Confirmed	Confirmed	Confirmed
Iran	Confirmed	Confirmed	Confirmed
Libya	Confirmed	Confirmed	Confirmed
North Korea	Confirmed	Confirmed	Confirmed
Sudan	None	Confirmed	Confirmed
Syria	None	Confirmed	Confirmed

Note: [1]India and South Korea declared having stockpiles of CW. (see Tucker et al., 2001)

Table 7. State Supporters of Terrorism and NBC Programs
Source: Joseph and Reichart 1999 p. 26.

There are several sources citing that the US forces blew up an ammunition depot at Khamisiyah; coalition air attacks struck CB facilities; and reports of detector alarms (US General Accounting Office 1993 and1998b). Conversely, studies modeling the release of nerve agents and mustards from such attacks indicate that significant transport of agent to the vicinity of US forces was unlikely (US Department of Defense 1997b). These same reports cited that there were concerns that low levels of exposure might have occurred from the US forces' attacks (US Department of Defense 1997b; US General Accounting Office Report 1993).

Additionally, the Office of the Special Assistant for Gulf War Illnesses' (OSAGWI) *Annual Report for 1997* cited that they knew of one chemical weapon exposure that involved US forces, which took place shortly after the defeat of Iraqi forces. The OSAGWI's report said that "in the process of destroying an Iraqi weapon depot at Khamisiyah, US forces blew up a bunker and stocks of rockets that contained the nerve agents sarin and cyclosarin without knowing that the rockets contained chemical warheads" (US Department of Defense 1997a). However, no casualties occurred, and it was only much later determined that they were destroyed and probably released during the demolition.

A second incident cited in the OSAGWI 1997 report involved a single US soldier who developed typical mustard agent--like blisters on his arm. The symptom occurred several hours after he was in an Iraqi bunker assisting in the destruction of Iraqi vehicles and military equipment (US Department of Defense 1997a). Whether the cause of the blisters was mustard agent in this event or some other source is currently unresolved, and investigative studies continue with this incident, as well as the ammunition depot incident, cited earlier.

Toxic Industrial Chemicals (TICs)

In both of these Persian Gulf War incidents, perhaps casualties resulted from the release of TICs. Several sources reviewed suspect that the low level CW agent fallout could have occurred as a result of US bombing of three Iraqi chemical weapon facilities in central Iraq--Muhammadiyat, Al Muthanna, and Ukhaydir (US General Accounting

Office 1993 and 1998b; US Department of Justice 2000). Additionally, the US Central Intelligence Agency (CIA) estimated that low levels of sarin and mustard were dispersed as far as 300 and 130 kilometers, respectively, from Muhammadiyat and that sarin was dispersed up to 160 kilometers from Al Muthanna (US General Accounting Office 1998b). Moreover, DOD identified twelve other instances of suspected CW agent exposures during Operation Desert Storm (US General Accounting Office 1998b).

These incidents of inadvertent releases of CW agents due to aerial bombing demonstrate low level exposure threats to US troops that can be encountered in future contingencies, when the adversary possesses CW research, production, or storage facilities. While less lethal on a gram-for-gram basis than current CW agents, TICs are often available in enormous quantities, do not require extensive research programs, are easily mass produced, and do not violate the Chemical Weapons Convention (CWC) (US Army 1998a; Tucker et al. 2001).

The CWC entered into force on 29 April 1997, serving as both a disarmament and a nonproliferation measure (Tucker et al. 2001). The CWC requires member states to destroy chemical weapon stockpiles and dedicated production facilities, and to renounce their reacquisition in the future. The Organization for the Prohibition of Chemical Weapons (OPCW), headquartered in The Hague, the Netherlands, is responsible for implementing the CWC (Tucker et al. 2001).

The CWC includes an annex classifying relevant CW agents and their most important precursors into three "schedules" based on their military potential and the extent of their legitimate civilian use (Tucker et al. 2001). Schedule-1 comprises known CW agents (e.g., sarin, VX, mustard gas) and their immediate precursors. Schedule-2 includes TICs that are utilized in small quantities for commercial purposes; and Schedule-3 includes TICs, such as phosgene and hydrogen cyanide, that are produced and consumed by industry in large quantities. Nevertheless, according to Tucker, “The CWC verification regime does not attempt to monitor all TIC; instead, declarations and inspections focus on the subset of treaty-relevant chemicals and activities that have been assessed to pose the greatest threat” (Tucker et al. 2001).

The CWC determines whether a chemical industry facility is declarable based on two criteria. The first criterion is whether it produces, processes, or consumes one or more of the chemicals listed on the schedules; and the second one is whether the annual amount of scheduled chemicals produced, processed, or consumed exceeds specified quantitative thresholds (Tucker et al. 2001). The quantitative declaration thresholds in the CWC are defined according to threat level. There is no threshold for the CW agents on Schedule-1; a threshold of 1-kilogram, 100-kilograms, or 1-metric ton for the various subcategories of chemicals on Schedule-2; and a threshold of 30-metric tons for the industrial dual-use chemicals on Schedule-3 (Tucker et al. 2001). However, facilities whose yearly production falls below the thresholds need not be declared (Tucker et al. 2001).

Industry representatives from the major chemical producing countries were deeply involved in the CWC negotiations. Tucker’s rationale for their involvement is that they believed “by establishing controls, reporting obligations, and facility inspections to verify compliance, the CWC would minimize the likelihood that legitimate commercial products could be diverted and misused for illicit purposes” (Tucker et al. 2001). Still, a variety of actions can result in the release of industrial chemicals (i.e., deliberately or accidentally released in a military situation). For example, the release of TICs could occur from industrial plants or storage depots through collateral battle damage (i.e., consequence of a strike against a designated target) (US Army 2001a). When exploring possible usage of TICs, in a COE or on an asymmetrical battlefield, then one might see adversaries targeting industrial plants and hazardous material containers (i.e., trains, planes, or boats) deliberately.

An estimated 25,000 commercial facilities worldwide produce, process, or stockpile chemicals that fall within the scope of the CWC (US Army 1998b; Hughart 1998). These include dual use chemicals, in other words, used for legitimate industrial purposes or as CW agents. Table 8 outlines a list of some of the common TICs.
Also cited in those two sources is the fact that there are "more than 70,000 different chemicals amounting to billions of tons of material produced, processed, or consumed by the global chemical industry." The Department of the Army sees many of these chemicals to be sufficiently hazardous to be a threat, either by deliberate or accidental release, in a military situation (US Army 1998a). They also make the argument that "if deployed in less traditional but increasingly significant stability and support operations (SASO), forces will often deploy into highly populated regions where the production, distribution, or use of TICs occur.

Additionally, the United States' Environmental Protection Agency (EPA) and the Department of Justice (DOJ) agree that, "a release of TICs--whether as a result of accidental or criminal activity--could have dire consequences" (US Department of Justice 2000). The DOJ's report concluded that an industrial chemical release is not likely to be used as a means of attacking a particular site, unless that site was in close enough proximity to the facility to assure that it would be affected by the release. It is more probable, however, that TICs "would be used for the broader terrorists' purposes of

Chemical	Appearance	Smell	Iritation
Ammonia	Colorless gas	Strong, acrid	Yes
Arsine	Colorless gas	Mild, garlic	No
Boron Trichloride	Colorless gas	Hydrochloric acid-like	Yes
Boron Trifluoride	Colorless gas	Pungent, suffocating	Yes
Carbon Disulfide	Faint yellow liquid	Sweet, ether-like	No
Chlorine	Greenish-yellow gas	Strong swimming pool	Yes
Diborane	Colorless gas	Repulsive, sweet	No
Ethylene Oxide	Colorless gas	Ether-like	Yes
Fluorine	Pale greenish-yellow gas	Pungent	Yes
Formaldehyde	Colorless gas	Pungent, suffocating	Yes
Hydrogen Bromide	Colorless gas	Sharp, irritating	Yes
Hydrogen Chloride	Colorless or light yellow gas	Pungent	Yes
Hydrogen Cyanide	Colorless or pale blue gas or liquid	Bitter, almond	No
Hydrogen Fluoride	Colorless gas or fuming liquid	Strong, irritating	Yes
Hydrogen Sulfide	Colorless gas	Rotten eggs	Yes
Nitric Acid	Colorless or yellow/red fuming liquid	Acrid, suffocating	Yes
Phosgene	Colorless gas	Suffocating, musty hay	Yes
Phosphorus Trichloride	Colorless to yellow fuming liquid	Hydrochloric acid-like	Yes
Sulfur Dioxide	Colorless gas	Pungent	Yes
Sulfuric Acid	Colorless to dark brown oily liquid	Odorless	Yes
Tungsten Hexafluoride	Light yellow liquid	Odorless	Yes

Table 8. Common Toxic Industrial Chemicals
Source: US Army 1998a, p. F-16

indiscriminately killing, harming, or threatening people in the surrounding community and damaging their property" (US Department of Justice 2000).

Moreover, the DOJ's report concluded, "even if not ultimately lethal, a TIC release would still cause widespread disruption, panic, and fear" (US Department of Justice 2000). Eliciting fear among the public is exactly the type of assault on the public psyche that is consistent with terrorism. This may offset a terrorist's concerns over limitations related to the inability to direct a chemical release. Furthermore, as the

Advisory Panel to Assess the Domestic Response Capabilities for Terrorism Involving WMD stated to the United States' president: "Terrorism, in essence, is a form of psychological warfare. The ultimate objective is to destroy the structural supports that give society its strength by both showing that the government is unable to fulfill its primary security function and, thereby, eliminating solidarity, cooperation, and interdependence on which social cohesion and functioning depend" (RAND Corporation 1999).

It is also noteworthy that the DOJ's report cites to a possible example of a terrorist causing the release of TICs by using a plane crash to breach a hazardous material container. This is also perhaps one of the most obvious means of attempting to rupture a large metal vessel. For example, chemical tanks have been intentionally ruptured during attacks involving explosives and have resulted in TIC releases that caused collateral damage. For instance, the war in Croatia was a major conflict in which industries were targeted with the intent to release TICs into the environment.

Although much has been written about the public health effects of Iraqi attacks on oil fields in Kuwait, relatively little has been written about attacks on the chemical infrastructure in Croatia. However, Joseph L. Hughart has written extensively on the topic for the Agency for Toxic Substances and Disease Registry (ATSDR) (Hughart 1998). In the process of "ethnic cleansing", entire towns and villages were destroyed (Hughart 1998). Hughart concluded that this was accomplished primarily by artillery attacks, followed by ground assaults by infantry units. However, he also cited casualties that were inflicted by releasing hazardous chemicals into the environment from industries located in villages and towns. This was attempted at the Petrochemia plant in the town of

Kutina, located in the western Slavonia sector of Croatia (Hughart 1998 and US Department of Justice 2000). Hughart discussed several conclusions drawn from the war in Croatia about TICs, and they are discussed in chapter 4 of this thesis.

Perhaps one of the important sources in the area of TIC is the *International Task Force 25* (*ITF-25*) document (Stuempfle et al. 1998). The document is a report from the United States, the United Kingdom, and Canada's meeting on chemical and biological defense (CBD). The *ITF-25* objective was to determine whether there is a hazard from the release of TIC during military operations. The final report released in March 1996 concluded that there are hazards related to the release of industrial chemicals during military operations, such as "war/conflict, peace-making (i.e., enforcing), peace-keeping, humanitarian aid, disaster relief, counter-terrorism, and counter-proliferation" (Stuempfle et al. 1998). (Author's note: Current US military doctrine defines peacemaking and peace enforcement as distinctly different operations, Stuempfle's comments notwithstanding.) Generally, there are sixteen types of military operations other than war (MOOTW) and the type that peacemaking and peace enforcement falls within is the peace operations' type of MOOTW operations (US Joint Chiefs of Staff 1995).

The *ITF-25* report also stated that TICs are legitimate articles of commerce, are widely produced and traded, and are available worldwide. The report identified several scenarios involving production, storage, and transport of industrial chemicals in which it is "highly likely" that Canadian, United Kingdom, and US "(CANUKUS)" forces will encounter TICs in military missions throughout the world (Stuempfle et al. 1998).

The *ITF-25* identifies an industrial chemical as a material capable of being produced in quantities exceeding thirty tons per year at one production facility and having a median lethal dosage of a vapor or aerosol LCt_{50} in any mammalian species of less than 100,000 mg min/m^3 (Stuempfle et al. 1998). The study only included chemicals that produce an acute inhalation effect. This excluded chemicals with chronic effects, or combustion products from fires (e.g., pyrolysis products of plastics), or carriers of compounds (e.g., asbestos laden smokes from building insulation). The study also excluded pesticides because of their low vapor pressure and because their exposure route is primarily cutaneous rather than by inhalation. However, the report recommended that pesticides warrant further investigation to determine if they present an immediate hazard in military operations.

The *ITF-25* identified 1,164 chemicals that met the toxicity criterion, and this number was furthered reduced to only consider those chemicals with an appreciable vapor pressure at twenty degrees C, or listed as "hazardous" in the US Department of Transportation Emergency Response Guide (Stuempfle et al. 1998). By applying these criteria to the 1,164 chemicals, the original list of chemicals was reduced to 98 chemicals for further consideration. They then developed a "Hazard Index (HI)" to further categorize the hazard. As shown by the equation below, the HI is the product of four toxicity producible factors: toxicity (immediately dangerous to life or health (IDLH), physical state global distribution, and number of producers:

HI = (IDLH concentration) x (state) x (distribution) x (producers)

As a result of the *ITF-25* report, there is now a HI Ranking List (see Appendix A on page 79) for TIC and a recommended safe hazard distance from a chemical plant, storage site, and rail depot. However, the *ITF-25* report fails to provide a definition for TICs. Nevertheless, based on the review of literature provided for this study, a possible definition might be as follows. A TIC is a chemical compound that has been found to be harmful to humans in low doses or can statistically be shown to be acutely toxic to or cause severe debilitating, irreversible, or adverse health effects in mammals.

CHAPTER 3

RESEARCH METHODOLOGY

This thesis uses a nesting of questions to answer the primary question: Do toxic industrial chemicals (TICs) pose a weapon of mass destruction (WMD) threat, and what are their effects on military joint doctrine for operations in chemical environments? This primary question focuses the research to answer four secondary questions. First, What is the military joint doctrine for operations in chemical environments? Second, What is a WMD threat? Third, What are CW agents? Finally, What are TICs and are they a threat? Subsequent questions provide supporting information to the secondary and succeeding sets of questions.

In the search for answers to the questions previously posed for this thesis, characteristics of two of the most commonly described research methods (i.e., historical and descriptive) were identified. A significant array of books, periodicals, government documents, and Internet materials dealing with WMD as they relate to CW agents' (i.e., TICs) toxicities at low levels were reviewed. For the purpose of this thesis, a "role" is either nonproliferation or a counterproliferation use. An example of these roles is illustrated in figure 1.

Nonproliferation use would be the full range of political, economic and diplomatic tools to prevent, constrain, or reverse the proliferation of WMD, their components, and their delivery systems (US Joint Chiefs of Staff 2001c). Counterproliferation use is the full range of military preparations and activities to reduce the threat posed by WMD and their delivery systems (US Joint Chiefs of Staff 2001c). Counterproliferation is primarily an American doctrinal concept. For example, the

European view of counterproliferation, while recognizing the necessity for military options and preparedness, places a greater emphasis on diplomatic, economic, and political means of countering WMD. Indeed, French and German officials insist that counterproliferation is not an acceptable NATO term because they believe that the US focus on retaliation and preemptive strikes could undermine nonproliferation efforts.

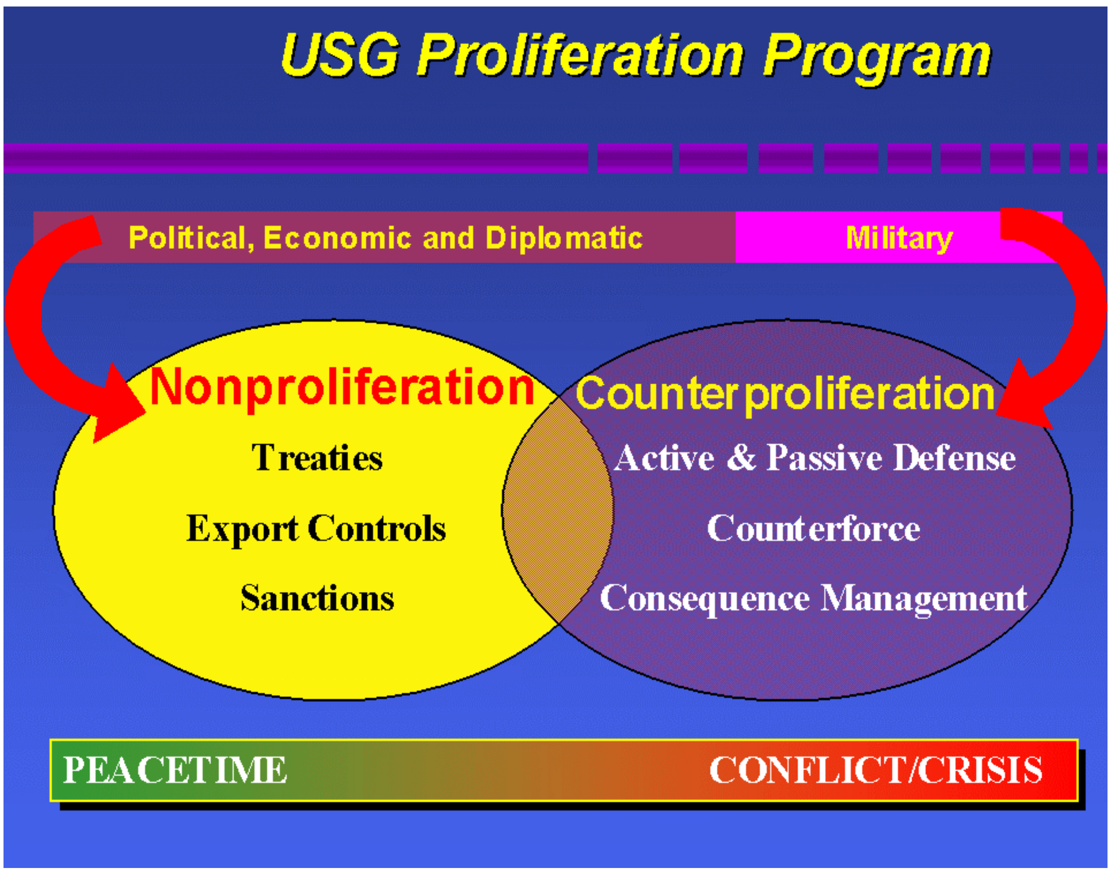

Figure 1. US Government's Proliferation Program
Source: US Joint Chiefs of Staff 2001c.

Although this study is exploratory in accordance with constraints, the author gathered evidence to conduct an analysis and answer the previously posed questions for this thesis. The literature review provided a strong historical and doctrinal perspective on the topic of WMD. The specific methodology for each question (to include the primary research question and its subordinate questions) follows.

Do TICs pose a WMD threat, and what are their effects on military joint doctrine for operations in chemical environments? This question easily lends itself to traditional library research and Internet searches. However, to best answer, this question required the development of subordinate questions that, once answered and consolidated, should provide the final answer to the research question. The four basic subordinate questions form a logical line that leads to the conclusion of this thesis.

The first subordinate question is, What is the military joint doctrine for operations in chemical environments? This question is answered early in chapter 1 with a detailed analysis applied in chapter 4. This question required extensive background reading of data collected from historical and current doctrinal background information pertaining to the joint staff and the services components as applicable. These sources included published and draft doctrine and program development related materials. This thesis also evaluated secondary sources that might include information from a public or privately funded research institute (e.g., Army Research Institute or RAND Corporation Corporation respectively). Consequently, this method of collecting data applies to each question in this thesis as a method to assess and to explain the body of information concerning the applicability of TIC to military joint doctrine for operations in chemical environments.

The second subordinate question is, What is a WMD threat? There are a variety of definitions for this acronym, and after the terrorist incident in the US on 11 September

2001, perhaps there are even more. This thesis defines the use of WMD from a joint doctrine perspective early in chapter 1, but after conducting the literature review, a significant number of sources identified a need to explore the concept of weapons of mass effects (WME). As this thesis defines WMD in chapter 1 with its linkage to TIC, it will also explain in the analysis and concluding chapters its linkage to WME in a COE. The second subordinate question also required background reading into terrorism, terrorist groups, and an understanding of the potential for terrorists acquiring WMD and WME. Therefore, in chapter 4 the author defines the threat in general terms, discussing the groups and organizations that pose the greatest threat in a COE. Sources in addition to the traditional library included the Internet and contacts made through the course of this project

The third question is, What are CW agents? The answer for this question appears in chapter 2. A number of books have dealt with the history and more recent development in the field of CW. Consequently, this thesis explores those sources through the method previously explained, and the purpose of this extensive exploratory search is to provide a valid reason for accepting the argument that TICs are analogous to CW agents. Finally, what are TICs, and are they a threat? The answer for this question appears in chapter 1 with a brief overview to provide the strategic approach underlying the research, but chapter 2 contains a detailed discussion to answer the question.

Fundamental to this thesis is a twofold objective. The first one is to provide an understanding of the emerging threats posed by TICs. Secondly, is to submit alternative solutions and or potential initiatives to meet the challenge of protecting the force in the contemporary operating environment. As with any research, it is necessary to establish first a baseline. The process examines the US's national guidance for military operations in chemical environments and assesses the defense essential capabilities needed to meet this guidance. This thesis applies expert depiction of future operational and geopolitical environments and then examines current defense capabilities to fight and win battles in the contemporary operating environment.

CHAPTER 4

ANALYSIS

Introduction and Overview

This chapter provides an analysis on a future WMD threat, which begins with a discussion about the threat and military joint doctrine for operations in a chemical environment and is followed with a discussion of WMD and TICs. As WMDs become increasingly available, the spectrum of plausible scenarios for CBRNE attacks in the future will become wide and varied. The ability of the US to prevent, deter, defeat, and respond decisively to CBRNE attacks against its citizens, whether these attacks occur domestically, in international waters or airspace, or on foreign soil, is one of the most challenging priorities facing the US today.

The US government has spent billions of dollars in an effort to counter the perceived WMD danger. Public interest in and fear of the phenomenon has led to extensive discussion within the media, government, and academia of the vulnerabilities of the US to terrorism, particularly involving WMD. This increased fear and public awareness of the issue have been accompanied, and fuelled, by a dramatic increase in "hoaxes and other low level incidents," as individuals and groups with a grievance have realized that merely by using a key word they can create considerable disruption and publicity for their cause (Monterey Institute of International Studies, 2000). This succession of incidents, in turn, has served to strengthen public and governmental concerns, reinforcing the belief that the US is facing a probable danger paralleled only by the threat of Soviet nuclear weapons during the Cold War.

The Threat

Intelligence sources estimate that over twenty countries have active chemical weapons programs (US Army Chemical School 1999). Although signatories to various conventions banning NBC warfare, several third world countries continue to develop, test, and evaluate CW agents, and the means to disseminate. The spread of these weapons "and the industrial capability for manufacture" to third world nations, coupled with the potential for US involvement in these areas in an operational or support capacity, increase the probability that "Joint Forces may encounter NBC weapons and TIM anywhere in the world" (US General Accounting Office 1998a).

The unprovoked events of 11 September 2001 serve as an indicator that the US for all its strength and vitality remains at risk in a changing and sometimes unpredictable world. While the terrorists who attacked the World Trade Center and Pentagon did not employ NBC weapons, their actions leave little doubt that such weapons, had they been available, would have been used. The weapon involved may categorize a terrorist act. In general, "terrorist weapons of mass-destruction fall into four categories: explosives, chemical and biological agents, and radioactive materials" (Allen1997; Grange 2000). Consequently, "the US now faces an acute challenge in NBC weapons proliferation--a principal asymmetric warfare capability" (National Defense University 2001).

The terrorists' attacks of September 11, 2001 demonstrate that the COE the US envisioned for the future is perhaps here now: "ambiguity, rapidity, asymmetry, and force protection" (Warren and Lindstrom 2000). These four terms are defined by the US Army's Training and Doctrine Command (TRADOC) Office of the Deputy Chief of Staff Intelligence's (ODCSINT) and depicted in Table 9. This COE concept perhaps is based on the *United States Commission on National Security /21st Century's September 15, 1999, Phase I Report*. The Commission was established to recommend a new strategy for the advancement of American interests and values.

Ambiguity – Future enemies will attempt to stay below the threshold of clear aggression and may be politically and psychologically astute.
Rapidity – The global trend is toward the compression of time, and adaptation and mutation will be fueled by communication and interconnectedness.
Asymmetry – Most enemies will attempt to exploit weaknesses of US military forces, while US forces are considered unequalled in the execution of conventional military operations.
Force Protection – Force protection is considered a primary element comprising the total combat power of a unit, and an act to conserve its fighting potential.

Table 9. Common Threads for the Contemporary Operation Environment (COE) Source: Warren and Lindstrom 2000, p. 2.

As a result, TRADOC published the *Future Operational and Threat Environment: A view of the World in 2015*, citing the *Phase I Report* as a source. The TRADOC white paper focuses on the period during 2015 to 2020 and concludes that the Army will operate in a geostrategic environment of considerable instability, driven by significant demographic, geopolitical, economic and technological dynamics (Warren and Lindstrom 2000). The realities of this environment, according to TRADOC, will force the Army to remain engaged in a wide variety of missions as increasing competition between states and groups for fiscal and other resources lead to conflicts involving the US. The conclusion is that the 2015 to 2020 period will be "extremely diverse and riddled with dangerous possibilities that the Army must develop new, adaptive and innovative capabilities to address the challenges" (Warren and Lindstrom 2000).

Some strategists would say this COE is nothing more than asymmetric warfare, which is "conflict deviating from the norm, or an indirect approach to affect a counterbalancing of force” (Grange 2000). Perhaps, since Desert Storm, the US’s adversaries have learned not to come at the US in a symmetric conventional warfare manner. Today the world is ambiguous, with people, groups, and governments pursuing complex goals. The borders have blurred between governments and people, military and populace, public and private, creating what TRADOC classifies as a COE, but others--asymmetric warfare.

Finally, assessing the threat is complicated by several interrelated changes, including the proliferation of weapons, technological advances, unstable political regimes, shifting regional power balances, and the increasing threat of terrorism. The threat will be exacerbated with continued and more frequent deployment of US forces worldwide. “The countries that are of greatest concern to the United States are located in regions in which the United States has well defined national security interests” (US Department of Defense 2001). Therefore, it is of paramount importance that the US continue to maintain a credible, robust capability to protect US forces and provide them capabilities to operate effectively in a chemically contaminated environment.

Joint Doctrine

Joint and service doctrine for conducting and sustaining operations in NBC environments is based on the following general principles: (1) contamination avoidance (detection, identification, warning and reporting and reconnaissance); (2) NBC protection (individual, collective and medical support); and (3) decontamination (Joint Publication 3-11 2000). Application of these principles help to minimize vulnerabilities, protect friendly forces, and maintain the force’s operational tempo to achieve campaign objectives while complicating adversary targeting (see figure 2).

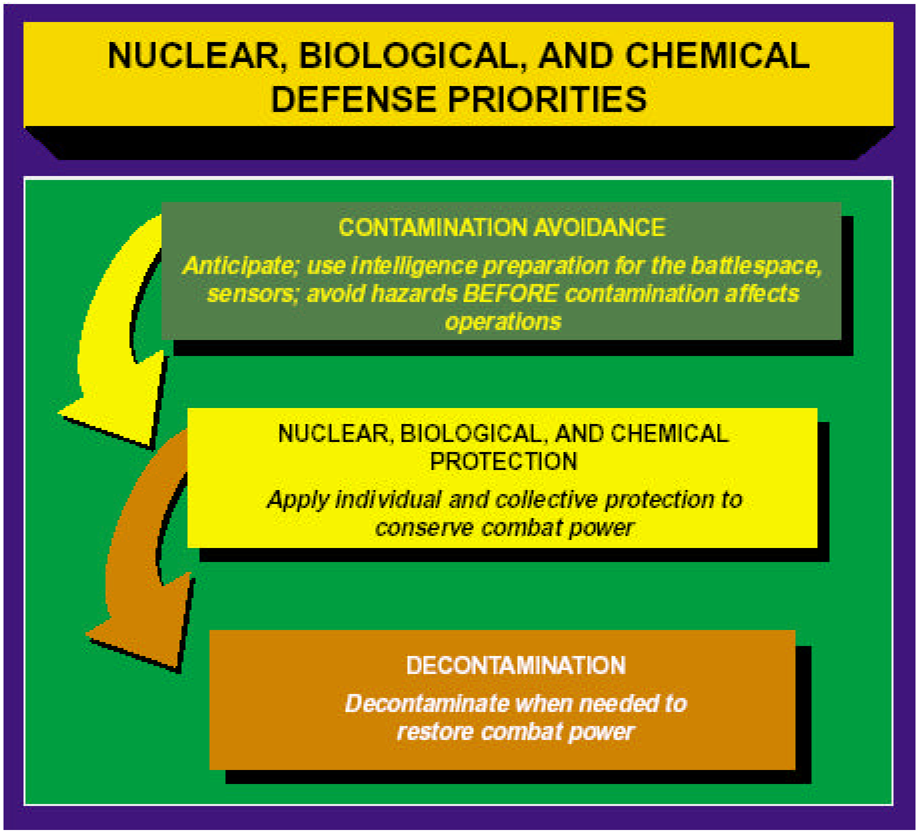

Figure 2, Nuclear, Biological, and Chemical Defense Principles
Source: US Joint Chiefs of Staff 2000, p. III-7.

Perhaps it is important to note two subordinate groups that play an important role in the joint doctrine arena. First, the Joint Service Integration Group (JSIG) is responsible for identifying joint CBD requirements and priorities, and for overseeing the development of appropriate training and doctrine. The JSIG also coordinates with the Joint Staff Joint Warfare Capability Assessment process to identify vulnerabilities and prioritize requirements. Second is the Joint Service Materiel Group (JSMG) that is responsible for identifying materiel solutions to the requirements and coordinating and integrating research, development and acquisition efforts. These groups perform the planning and programming functions for CBD research, development and acquisition and submit appropriate documentation to the Office of the Secretary of Defense throughout the Planning, Programming, and Budgeting System (PPBS) cycle.

The US Army Chemical School, supported by the Joint Staff, developed and revised joint doctrine for operations in NBC environments--Joint Publication 3-11. This revised doctrine offers current and specific joint guidance on principles of NBC operations across the spectrum of conflict: from peacetime preparedness through combat operations and post-conflict, to include military operations other than war. Specific areas of emphasis include fundamentals of NBC defense; planning for operations in an NBC environment; and logistical and medical support.

Toxic industrial chemicals are briefly mentioned in Joint Publication 3-11, Joint Doctrine for Operations in Nuclear, Biological, and Chemical Environments, which provides a general overview of NBC defense operations. It is also mentioned in the 27 December 2001 draft Joint Publication 3-40, *Joint Doctrine for Counterproliferation Operations*. As a framework for military counterproliferation operations takes shape, the Joint Staff and military services are focusing on the doctrine, operational concept, and training to prepare forces for an NBC environment.

The material in Joint Publications 3-11 and 3-40 on TICs are useful considerations at the conceptual level, but the joint doctrine is inherently limited by the shortfalls in hard intelligence on adversary intentions, capabilities, and plans concerning TICs. The joint doctrine in general for TIC is confined either to very broad statements about the effects or to detailed technical data on the types of TICs and operational safe distances. Only by embedding the enemy’s concepts into joint doctrine can the Armed

Forces develop courses of action above the individual and small unit level to counter the TIC threat to US forces.

If joint doctrine fails to take into account the enemy's TIC employment concepts, then the tactics, techniques, and procedures (TTP) needed to overcome essential vulnerabilities will not be developed. There are three possible vulnerabilities: protection of facilities such as ports and pre-positioning depots, large groups of personnel, and of essential equipment and supplies; decontamination capabilities for large areas and sensitive materiel such as airfields and aircraft; and handling of contaminated casualties and cargoes. Moreover, without such concepts, the US might miss an opportunity to recognize and correct the vulnerabilities in the US NBC posture.

The enemy's military concepts are recognized as essential for the DOD development of service and joint doctrine operating principles for defensive and offensive operations. Concepts of enemy conventional operations are fully embedded in doctrine, force development, and training. Therefore, the DOD's failure to develop and embed similar concepts relating to NBC may expose forces in the field and fleet to risks that could have been mitigated had likely employment concepts been understood and corrective action taken.

Additionally, a recent report of the National Defense University, concluded, "analytic gaps persist" (National Defense University 2001). For example, many of the traditional, campaign-level models used to analyze military operations are limited in their ability to integrate CW considerations. Solutions will be found only when existing vulnerabilities are acknowledged and the Armed Forces begin to think comprehensively about how to overcome them. A more complete range of military operations subject to analytic scrutiny for their vulnerability to NBC attacks is needed. Forces in the field and fleet otherwise might not be prepared to perform within the NBC environment. It should be noted, however, those weaknesses (i.e., analytic gaps) do not mean the joint community and services have failed to address the challenge concerning TICs. No one should expect them to have resolved all the difficult problems associated with this complex and growing threat.

Weapons of Mass Destruction

The major problem in assessing or accepting the likelihood or the possible impact of TICs as a WMD is the definition of WMD. Many of the terms and definitions that are essential to this discussion are ambiguous and confusing. The *Advisory Panel to Assess Domestic Response Capability for Terrorist Incidents Involving Weapons of Mass Destruction*, noted in its *1999 First Annual Report to the President and Congress*, that "there is no agreement across the US government on what constitutes WMD." For the purposes of this paper, WMD mean "any weapon or device that is intended, or has the capability, to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of toxic or poisonous chemicals or their precursors, a disease organism, or radiation or radioactivity" (Public Law 104-201 1996).

The main catalysts behind Public Law 104-201 perhaps were the 1995 sarin nerve gas attack on the Tokyo subway and Timothy McVeigh's truck bomb to demolish a US federal building in Oklahoma City. The following year, Congress passed Public Law 104-201, "The Defense Against Weapons of Mass Destruction Act," also known as the Nunn-Lugar-Domenici (NLD) Act. This legislation sought to "reduce the nation's vulnerability to terrorist attacks, especially those involving mass casualties and or

CBRNE weapons" (RAND Corporation 1999). Among other things, the NLD Act required the DOD to "carry out a program to provide civilian personnel of Federal, state, and local agencies with training and expert advice materials" (Public Law 104-201).

The Joint Task Force Civil Support (JTF-CS) has the mission to plan and integrate DOD's support to the Federal Emergency Management Agency (FEMA) for WMD events within the US. This support will involve capabilities drawn from throughout the DOD, including detection, decontamination, medical, and logistical assets (US General Accounting Office 2001). The JTF-CS's operational focus is to respond to a WMD event, which is defined as "a deliberate or unintentional event involving a nuclear, biological, chemical, radiological weapon or device, or large conventional explosive, that produces catastrophic loss of life or property" (US General Accounting Office 2001).

The DOD's mission (i.e., providing military support to civil authorities) is not new, but JTF-CS's operational focus is. The definition of WMD, therefore, matters on at least two levels. First, in order to assess the threat and countermeasures involved, it is imperative that there is an understanding of the danger against which the US NBC defense principles intend to respond. Secondly, a major argument of this thesis is that TICs are synonymous with CW agents and are therefore massively destructive. Therefore, it is important to specify what is intended by a reference to WMD.

The DOD's joint doctrine, to include JTF-CS's definition, intended to protect against WMD is based on a limited definition of the issue. The JP 1-02, DOD Dictionary of Military and Associated Terms, defines WMD as " . . . weapons that are capable of a high order of destruction and/or of being used in such a manner as to destroy large numbers of people. Can be nuclear, chemical, biological, and radiological weapons . . . ."

Other authors and official sources define WMD in slightly different ways. For example, the WMD definition used by the Center for Nonproliferation Studies at the Monterey Institute of International Studies in Monterey, California, for its database of worldwide incidents involving CBRNE is broad. The Center for Nonproliferation Studies' WMD definition refer to all CBRNE materials as WMD, even though only a few of the incidents discussed in its database involved mass destruction or mass casualties (Monterey Institute of International Studies 2000). This definition of WMD is more in line with the legislative intent of Public Law 104-201, "The Defense Against Weapons of Mass Destruction Act." The JP 1-02's WMD definition, on the other hand, completely excludes "serious bodily injury" which is found in Public Law 104-201.

The definition of WMD raises a number of questions: Does it depend on the type of weapon used or on the results achieved with that weapon? What is mass destruction in this context--physical destruction, casualties, or disruption? What is the level of each that would qualify an incident as mass destructive? Physical destruction is clearly not a defining characteristic of WMD, although it may be a consequence of it. Disruption is also a likely result of WMD, but cannot be used to determine whether an incident should be classified as involving a WMD. Casualties, as the most obvious consequence of a WMD attack, should therefore be at the center of any definition of WMD.

Does the definition depend also on the type of agent or material used, or solely on the capability of the weapon? Certain WMD might not be used to cause widespread death, but to produce non-fatal illnesses as a means of disruption in objectives, phases, and courses of action. Some types of chemical incidents are self-evidently examples of WMD (e.g., the release of a chemical agent that caused destruction, disruption, or casualties). Common sense dictates that the classification of an incident has to rest on its effects, or at least on its potential effects, rather than simply on the type of weapon that is used.

As cited in the recent released JP 3-60, *Joint Doctrine for Targeting*, during military operations, “targeting must be focused on to create specific effects to achieve a particular objective” (US Joint Chiefs of Staff 2002). This is exactly what an adversary or terrorist’s leader is seeking to accomplish when they use WMD. For example, an attack on an industrial factory--or caused by collateral damage--is not necessary to destroy it, but to cause an effect against the US center of gravity or decisive point. A WMD is not critical in and of itself. Rather, its importance is derived from its potential contribution to achieving the adversary or terrorist’s desired strategic, operational, or tactical effect.

Weapons of mass destruction (i.e., TIC) targets may include the wide array of mobile and stationary forces, equipment, and other military resources that an adversary commander can use to conduct operations at any level of war. Perhaps, therefore, a more appropriate definition for WMD is the one used in the US Domestic Preparedness Program (officially The Defense Against WMD Act of 1996) that was part of the National Defense Authorization Act for Fiscal Year 1997. Specifically, in section 1403, it defines WMD as “ . . . any weapon or device that is intended, or has the capability, to cause death or serious bodily injury to a significant number of people through the release dissemination, or impact of toxic or poisonous chemicals or their precursors, a disease organism, or radiation or radioactivity” (Public Law 104-201, 1996). As shown in this thesis, TICs can be as highly toxic as chemical weapons, and they have the capability to cause serious bodily harm. Therefore, according to Public Law 104-201 TICs are WMD.

CW Agents

A chemical agent may be defined as a compound, which through its chemical properties produces lethal or damaging effects in humans, animals, plants or materials. Unlike biological agents, chemical agents are usually manmade by industrial chemical processes. Some of today's chemical agents are hundreds of times more potent than those used in World War I. CW agents reappeared on the military battlefield in the 1980's when it was confirmed that mustard and the nerve agent Tabun (GA) were used by Iraq against Iran.

The lessons drawn from the Gulf War are of a mixed nature. What the United States learned from that conflict was that US capabilities to deal with the threat of NBC attacks were "inadequate in terms of training, doctrine, and equipment" (US General Accounting Office 1998b). What our potential adversaries learned was that they could not compete with superior conventional military power. Therefore, asymmetric means of challenging the United States might have to be employed should a conflict arise. Such means include the possible use of WMD against US forces.

Chemical weapons were originally designed for use on the military battlefield to injure, incapacitate or kill the enemy. The use of CW agents in World War I began with chlorine and phosgene, both of which are choking agents. In fact, these two chemicals were common industrial chemicals well before their use in World War I as CW agents. The lesson learned from World War I is that TICs could be used as a WMD. More recently, the DOJ's report concluded that even if not ultimately lethal, a TIC release is probable and could cause widespread disruption, panic, and fear (US Department of Justice 2000). Therefore, perhaps it is fair to assume that future US stability and support operations will see more chemical compounds (see table 8) used as CW agents by adversaries or terrorists.

In a collection of reports edited by Jonathan Tucker, one of the authors writes that "[m]any industrial chemicals are so toxic that they could be used either in conventional warfare or for terrorist attacks against civilians" (Tucker 2001). The author, George Parshall, also writes that the Chemical Weapons Convention (CWC) was created with the recognition that it is impossible to envision every way in which toxic chemicals might be used for aggressive purposes (Tucker 2001). One major trend is an increased emphasis on the production of chemicals that have desirable biological effects, such as pharmaceuticals, crop protection chemicals, flavors, and fragrances (Chopey et al. 1997). The methods developed for the discovery and production of these useful products are equally applicable to finding and making CW agents. Moreover, the diffusion of these technologies is such that perhaps the Organization for the Prohibition of Chemical Weapons (OPCW) alone cannot ensure effective control.

Toxic Industrial Chemicals

Nuclear, biological, and chemical proliferation is recognized as a serious threat across the operational spectrum--from the deployment of forces to post-hostility activities, but there is a misconception when it comes to TIC as equal to CW agent threats. Actually, common industrial and agricultural chemicals can be as highly toxic as chemical weapons. The widespread use of TICs make them attractive to terrorists or adversaries to cause people and businesses fear and hurt.

Assessing the threat of TIC remains difficult despite extensive literature bases in terrorism studies and WMD studies. In the absence of sufficient empirical data and analysis, policymakers and analysts often make projections based on assumptions about the increasing spread of WMD-related technology and know-how, and the vulnerability of modern society to WMD attack. Industrial chemicals such as chlorine, sulfuric acid and hydrochloric acid potentially provide terrorists with "effective and readily accessible materials to develop improvised explosives, incendiaries and poisons," and continue to go unaccountable as a WMD, according to a 1999 study (Hughart 1998).

Toxic industrial chemicals (i.e., chlorine, phosgene, and hydrogen cyanide) can be bought on the commercial market or stolen, thus avoiding the need to manufacture them. Experts from the scientific, intelligence, and law enforcement communities agreed that TICs can cause mass casualties and require little if any expertise or sophisticated methods for development (US General Accounting Office 1999). The report also cited that unlike TICs most G and V chemical nerve agents are technically challenging for terrorists to acquire, manufacture, and produce. The experts interviewed were individuals with expertise in the disciplines of chemistry, biology, virology, microbiology, physics, and meteorology. The Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving WMD concluded that the terrorists' purpose would be to "engineer the hazardous release of a toxic gas or gases as a means to kill and injure surrounding populations" (RAND Corporation 1999). Some TICs that have properties similar to military CW agents are illustrated in table 10 (Hughart and Bashor 1998). A terrorist release of these TICs could inflict the same damage as a military CW agent, albeit larger quantities of the TIC would be required. In other words, many common hazardous materials used in industry today pose the same threat as the chemicals classified as nerve, blister, blood, and choking agents. Therefore, adversaries or terrorists may target facilities or industries that use or store these common TICs shown in table 10 (*see also* table 8 in Chapter II) as a WMD.

Common TICs	Effects of CW Agents
Organophosphate Insecticide	Nerve
Dimethyl Sulfate	Blister
Methyl Isocyanate	Blood
Anhydrous Ammonia	Choking

Table 10. Comparison of Common TICs to CW Agents
Source: Hughart and Bashor 1998; US Army 1990 and 1998a

Much has been written about the public health effects of Iraqi attacks on oil fields in Kuwait, but relatively little has been written about the attacks on chemical infrastructure in Croatia via improvised methods. The war in Croatia was the second major conflict within the past decade in which industries where targeted with the intent to release hazardous chemicals in to the environment. For example, Reuters International Press reported that grenades filled with chlorine obtained from industrial sources were used during the war in Bosnia (Hughart 1998; US General Accounting Office 1993). The number of casualties apparently was low, reflecting the French experience in World War I when chlorine failed to produce mass casualties because it was released in small amounts in open areas.

Chlorine hazards should not be underestimated just because they are less toxic than CW agents. Large chlorine releases from rail cars, large storage tanks, or tank trucks in enclosed areas such as narrow streets in urban areas pose substantial hazards.

There are actually two possible situations where a TIC (e.g., chlorine) could pose substantial hazards. One involves the effects of the chlorine release against protected troops. The other involves the effects upon the unprotected civilian population (i.e., noncombatant civilian). In these situations, chlorine can be an effective improvised choking agent.

Such a situation was illustrated at the Pliva Pharmaceutical Factory in the northwestern sector of Zagreb, the capital of Croatia, during the war in Bosnia (Hughart 1998). Pliva Factory used acids, ammonia, chlorine, and other hazardous substances to produce pharmaceutical products. Croatian modeling indicated that, in case of a major attack, lethal concentrations of chlorine would extend to four kilometers away from the facility (Hughart 1998). Zagreb and Pliva were bombed during air attacks later in the war, but fortunately due to the prior planning, it led to residents being evacuated versus a victim.

During the war in Croatia, petroleum production facilities were also attacked with the intent of releasing toxic fumes (e.g., as combustion byproducts). Serbian forces attacked fuel storage tanks at Osijek, Sisak, and Karlovak (Hughart 1998). Other chemical plants attacked during the war included a natural gas refinery in the city of Ivanic, the town of Ivanic resulted in ammonia released, and the city of Sisak's pesticide plant (Hughart 1998). The Serbs were targeting industries with the intent of releasing hazardous chemicals into the environment as another means of accomplishing their objective--ethnic cleansing of towns and villages. Examples of the Serbian military's efforts to create chemical releases are particularly troubling because "terrorist organizations sympathetic to Serbian causes are currently operating in the United States" (US Department of Justice 2000).

Airplanes, boats, trains, trucks, and pipelines can also be used as improvised weapons to deliver large quantities of chemicals directly to targets located great distances from stationary sources of industrial materials (Tucker 1996; Hughart 1998). Some of the TICs used or produced in industries throughout the US and transported through densely populated areas have the potential to cause those facilities or locomotives to be vulnerable targets as was seen in the war in Croatia. A single attack on any of the chemical plants operating in the US potentially could match or exceed the 1984 disaster in Bhopal, India.

The 1984 Bhopal, India, catastrophe demonstrated exactly what could happen during a TIC explosion, when unleashed on a nearby populace. In that incident, a disgruntled employee at a pesticide plant caused an explosion in one of the storage tanks by simply adding water to it. In the massive release of methyl isocyanate that followed, noxious fumes affected thousands of people living near the plant. Four months later, over a thousand persons were reported to have died as a direct result of the leak (Hughart 1998).

Chemical tanks have been intentionally ruptured during attacks involving explosives and have resulted in chemical releases, some of which have produced grave damage. In December 1995, members of the Revolutionary Armed Force of Colombia (FARC), Colombia's largest guerrilla group, blew up a pesticides warehouse in Une, Colombia, resulting in large volumes of toxic materials being released into the air (US Department of Justice 2000). Approximately 9,000 people living near the warehouse were evacuated in order to prevent mass poisoning from the toxic emissions. It is noteworthy that the FARC has sympathizers in the United States and the FARC in Colombia has threatened US air carriers (US Department of Justice 2000).

Today's perceptions of combat operations widely held within the US and abroad, have been seen through the lens of Desert Storm, Bosnia, and Kosovo. The lesson learned is that the US has no identified conventional, war-making competitor. The absence of global competitors makes the world more uncertain, unstable, and difficult to anticipate. As the sole superpower and extensive presence around the world, the US has become a big and inviting target. Since Desert Storm, adversaries have learned not to attack the US in a symmetric way since it is impossible for any country to engage the US in an arms race. Potential adversaries will perhaps modernize their military capabilities in light of Desert Storm, Bosnia, and Kosovo conflicts, and resort to unconventional tactics (i.e., asymmetric warfare).

Despite continuing gaps in hard intelligence, the threat is "asymmetrical and not monolithic" (National Defense University 2001). Adversaries may elect to employ one or more chemical weapon types to inflict either varied or synergistic effects. While the term WMD retains some political utility, the written Joint doctrine increasingly fails to reflect the more complex reality that chemical weapons differ considerably across a range of attributes, including their ability to inflict mass destruction effects. A strategist or planner, therefore, must begin to look at chemical weapons in terms of both threat and response.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Since NBC proliferation currently represents one of the major threats facing the US in the "war on terrorism," the Joint Staff and the combatant commands should reassess the numbers and types of NBC units needed to execute current war plans and other statutory functions and responsibilities. While the DOD's counterproliferation and consequence management policies continue to develop in meeting overall requirements for operating in an NBC environment, considerable work is needed in both individual Service and joint arenas to assess the TIC threat. The current overall NBC threat suggests the need for a joint review of the organizational designs of the Services' NBC-related units that perhaps still reflect Cold War requirements, and are inadequate to cope with an asymmetrical TIC threat.

For centuries, war has involved the use of chemicals in the forms of both collateral damage and deliberate destruction. This century has seen a steady increase in adversaries attacking TIC targets and the percentage of civilian victims of war as well as an increase for damage caused by war. Since 11 September 2001, news articles about the WMD threat are on the televisions seemingly every night. The WMD threat is not nearly as clear as during the Cold War, when the US security environment had an appearance of predictability. The US knew its adversary--an expansionist empire, with forces ready to march across Europe, surrogate armies seeking to overthrow the US allies and install regimes around the world, and a massive nuclear arsenal pointed at US cities. Today, the

US must plan for a world of new and different adversaries who will rely on surprise, deception, and asymmetric WMD (i.e., TICs) to achieve their objectives.

The US came under a new and different attack, 11 September 2001, not by traditional armies waging traditional military campaigns, but by hidden enemies, willing and able to strike civilians where they live and work. These attacks were a wake-up call, a warning that the US is entering a dangerous new period in American history. The likely dangers of this new century will be quite different from those of the past one, one in which the United States' historical invulnerability will be replaced by vulnerability. What this means is that rather than the US planning for conventional wars in defined theatres, the future operational environment will be less predictable than will require a different type of response from US armed forces.

Current US doctrine and supporting force design has provided the US military with significant overmatch against established forces operating with a conventional strategy and doctrine. Most nations understand how US forces will fight and for what types of environments they are best suited. Using this knowledge, future opponents will seek to avoid US type operations in environments for which US abilities are optimized. Therefore, based on the trends shown in this thesis, future adversaries will adopt asymmetrical means and seek to operate from complex terrain as the most effective way to deal with US conventional forces.

Beyond conventional warfare considerations, it is also important to recognize that the US in recent years has become the prime target for international terrorists. As shown in this thesis, the risk of terrorists attempting in the near future to cause and industrial chemical release is both real and credible. The US now faces an acute challenge in chemical weapons (i.e., TICs)--a principal asymmetric warfare capability. These weapons or TIC targets pose a diverse array of risks to US armed forces, noncombatants, and to the US homeland itself. This thesis concludes that in the hands of terrorist, aggressive states or nonstates actors, TICs will serve as WMD, undermine regional stability, and threaten US interests.

Toxic industrial chemicals are not only more accessible in the United States, they are used worldwide and much cheaper than the average military agent. A TIC threat to a chemical, petrochemical, oil, pharmaceutical, biochemical, food and other industries could result in the release of TICs with catastrophic consequences, perhaps to an even larger extent than if chemical weapons had actually been used. As the technology of weapons has advanced, so too has the technological level of the targets that are selected. The desire to cripple an enemy's ability to wage war leads to the targeting of industrial facilities. Therefore, for the reasons cited above and throughout this thesis, it is fair to conclude that TICs are WMD and will play a role in future combat and noncombat environments.

The threat posed by these future predictions should radically alter the way the DOD’s Joint Staff thinks about and plans for force composition, forward presence, force projection, and the conduct of combat operations. The post-Cold War period is already nearly a decade old and that decade has been revealing. What strategists should distill from this past decade is that asymmetrical threats will continue to challenge US national security and economic security. For all of these reasons, it is essential that joint doctrine be expanded to think differently about the future TIC threat. Joint Publication 3-11, therefore, needs to clearly define TIM and TICs to meet the complex and uncertain national-security challenges of the twenty-first century.

The future challenge of the twenty-first century will be terrorists or adversaries' using or targeting new and different WMD such as chemical weapons (i.e., TICs). As weapons of opportunity, TICs are unmatched in variety and accessibility. As shown in this thesis, virtually everyone, including regional powers, Third World nations, sub-national organizations, terrorist groups, and individuals have immediate access to a variety of TICs. Although perceived, as not as deadly as conventional chemical agents, this thesis showed that TICs could be effectively used (e.g., the war in Croatia) as a weapon, a means of harassment, or a means of gaining media attention.

For example, future adversaries may see TICs not as instruments of last resort, but rather as weapons of choice to gain political, psychological or military advantages, especially when faced with conventional superiority. Toxic industrial chemicals may affect the nature of coalition warfare in three possible scenarios. First, an adversary may seek to hold hostage or strike critical ports and airfields essential for the deployment of coalition forces to the theater of conflict. Second, an adversary might understand the fragile political nature of coalitions--as seen in the war in Bosnia--and may seek to exploit differences among the partners through threats or intimidation. As was seen in the war in Croatia, TICs provide an unique asset to accomplish these objectives, or third, an adversary might exploit coalition forces that may be equally capable of operating in a chemical environment. Such differences in coalition capabilities can be readily exploited by the adversary to cause less prepared coalition partners to refrain from participation or to defect.

An increasingly important force protection issue for DOD is the Homeland Defense mission and the potential for first responders' exposure to chemical hazards. Unfortunately, this concern is not emphasized and planned for all units that may be employed in future military operations or conflicts. Operational environments, from humanitarian mission to theater-level combat, are becoming more dangerous simply because of the ubiquitous risks posed by TICs. For example, personnel deployed in support of missions ranging from war to operations other than war may be exposed to harmful chemicals because of industrial accidents, sabotage, or the intentional or unintentional actions of enemy or friendly forces.

Terrorists are also likely to view the potential of a chemical release from an industrial facility as a relatively attractive means of achieving their goals. They would--and have done so in the past--attempt to obtain or produce WMD precisely because such weapons are engineered to cause wide-scale damage to life and property. As cited in this thesis, some argue that creating or obtaining WMD are generally difficult to execute. In contrast, breaching a containment vessel of an industrial facility with an explosive or otherwise causing a chemical release is relatively simple for a terrorist.

The agents used by a terrorist may not be the traditional chemical weapons. Although vesicant and nerve agents have a high potential for use, terrorists can easily obtain TICs. A rail car containing phosgene, command detonated as it passes through a city, can be just as effective a terrorist device as a man-packed container of sarin. In other words, a terrorist does not have to be so concerned with specific characteristics sought in military agents such as stability in storage and non-transmission from person to person. In producing military agents, high purity was a goal, both for better agent stability and overall munitions efficiency. The terrorist, however, will likely produce an agent shortly before use, and has little concern for absolute purity (e.g., Aum Shinrikyo chemical attack in Yokohama, Japan.).

As DOD and Services perform their transitions into this new era, they will need to define the range of a potential adversary's chemical use and refine their NBC capabilities and force structures. In general, joint doctrine for combat and noncombat operations inadequately take account of current TIC realities. Based on the documents cited in this thesis, the US Armed Forces have not collectively identified overall force structure requirements for dealing with this threat. Joint doctrine publications also do not provide friendly concepts of operations that deal with likely or plausible TIC environments. Development of joint doctrine, tactics, techniques, and procedures for combat in various TIC scenarios are substantially lacking. Consequently, the training, leader development, force development, and materiel activities that are based on these doctrines inadequately deal with the threat.

Force structure adequacy for NBC matters is essential, which means that DOD might need to refine it to reflect additional NBC units, and modifications. Each military service within in DOD should have an asset capable of a rapid response to chemical attacks initiated by terrorists or during a military conflict. A typical rapid deployable chemical unit might include reconnaissance, detection, decontamination, medical, security, and service support elements. With these capabilities under one unit, the unit commander has the ability to provide command and control support to the incident site commander; conduct detection in a contaminated environment; insert medical assistance; and decontaminate the victims as needed. This type of unit needs to be available to a commander creating a battalion task force team to accomplish a mission in a contemporary operational environment. Additionally, this rapid deployable chemical unit would need to actively be a part of the combined and joint training centers.

Most military officers lack the expertise and training in NBC considerations. The problems and challenges associated with defending against chemical weapons attacks, or operating in contaminated environments, are not receiving adequate attention. There are fundamental differences within DOD about TIC threats to US military operations; some take the threat seriously and others discount it. Individual institutions within DOD tend to lack a commonly shared appreciation of the current and foreseeable TIC threat. These differences could be attributed to inadequate professional military education and leader development programs for NBC operations.

Given the varied dimensions and manifestations of the "war on terrorism" the Joint Staff and Services should review the appropriateness of their military education programs' NBC content and make required adjustments. Current simulations, which form the basis of much individual and unit training, do not realistically depict potential chemical weapons (i.e. TICs) use in today's likely combat and noncombat contingencies (e.g., JTF-CS mission for WMD). The essential near-term requirement is the development of an interactive method to enable commanders, planners, and key policy officials to improve their understanding of the challenges of operations in a chemical environment.

The principal recommendation for the shortfalls cited in this thesis is that the Joint Staff and Services should undertake a deliberate effort to improve NBC play in models, simulations, and combat training centers (CTCs) used to support training and force development activities. In other words, standardization across services and among combat and supporting organizations should be a goal of these efforts. Together with revisions to doctrine, improvements in leader development programs are crucial to developing appropriate military capabilities to deal successfully with TICs. While the development of predictive models will take time and effort, currently used models, simulations and CTCs can be improved for the near-term without entailing major costs and time delays.

High	Medium	Low
Ammonia	Acetone cyanohydrin	Allyl isothiocyanate
Arsine	Acrolein	Arsenic trichloride
Boron trichloride	Acrylonitffle	Bromine
Boron trifluoride	Allyl alcohol	Bromine chloride
Carbon disulfide	Allyl amine	Bromine pentafluoride
Cworine	Allyl chlorocarbonate	Carbonyl fluoride
Diborane	Boron tribromide	Chlorine pentafluoride
Ethylene oxide	Carbon monoxide	Chlorine trifluoride
Fluorine	Carbonyl sulfide	Chloroacetaldehyde
Formaldehyde	Chloroacetone	Chloroacetyl chloride
Hydrogen bromide	Chloroacetonitrile	Cyanogen
Hydrogen chloride	Chlorosulfonic acid	Diphenylmethane-4'-diisocyanate
Hydrogen cyanide	Crotonaldehyde	Ethyl chloroformate
Hydrogen fluoride	Diketene	Ethylene imine
Hydrogen sulfide	1,2-dimethyl hydrazine	Ethyl phosphonothioicdichloridie
Nitric acid, fuming	Dimethyl sulfate	Ethyl phosphonous dichloride
Phosgene	Ethylene dibromide	Hexachlorocyclopentadiene
Phosphorus trichloride	Hydrogen selenide	Hydrogen iodide
Sulfur dioxide	Iron pentacarbonyl	Isobutyl chloroformate
Tungsten hexafluroide	Mehtanesulfonyl chloride	Isopropyl chloroformate
	Methyl bromide	Isopropyl isocyanate
	Methyl chloroformate	N-butyl chloroformate
	Methyl chlorosuane	Nitric oxide
	Methyl hydrazine	N-propyl chloroformate
	Methyl isocyanate	Parathion
	Mehtyl mercaptan	Perchloromethyl mercaptan
	N-butyl isocyanate	Sec-butyl isocynate
	Nitrogen dioxide	Sulfuryl fluoride
	Phosphine	Tert-butyl isocyanate
	Phosphorus pentafluoride	Tetraethyl lead
	Selenium hexafluoride	Tetraethyl pyrophosphate
	Silicon tetrafluoride	Tetraethyl lead
	Stibine	Toluene 2,4-diisocyanate
	Sulfur trioxide	Toluene 2,6-diisocyanate
	Sulfuryl chloride	
	Tellurium hexafluoride	
	Tert-octyl mercaptan	
	Titanium tetrachloride	
	Trichloroacetyl chloride	

Appendix A. Chemical Hazard Index Ranking
Source: Stuempfle et al., 1998.

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